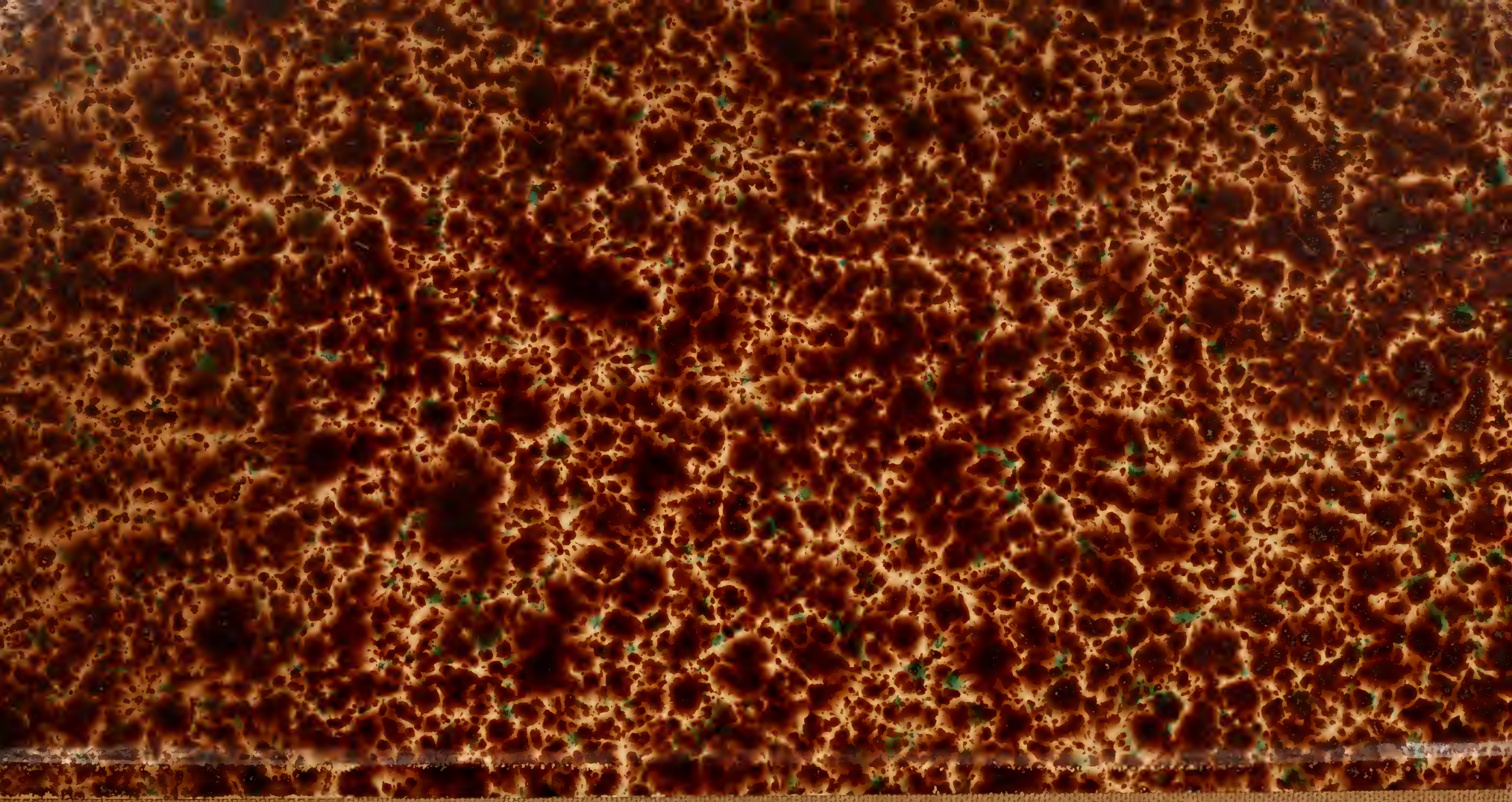


DEPARTMENT OF THE INTERIOR—U. S. GEOLOGICAL SURVEY
CHARLES D. WALCOTT, DIRECTOR

THE STRATIGRAPHIC SUCCESSION

OF THE

FOSSIL FLORAS OF THE POTTSVILLE FORMATION

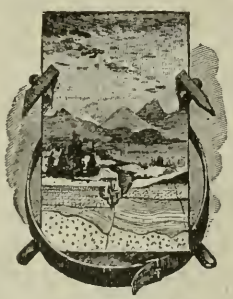
IN THE

SOUTHERN ANTHRACITE COAL FIELD, PENNSYLVANIA

BY

DAVID WHITE

EXTRACT FROM THE TWENTIETH ANNUAL REPORT OF THE SURVEY, 1898–99
PART II—GENERAL GEOLOGY AND PALEONTOLOGY



WASHINGTON
GOVERNMENT PRINTING OFFICE
1900

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PENNSYLVANIA

BY

DAVID WHITE

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By David White.

INTRODUCTION.

APPLICATION OF THE TERM "POTTSVILLE FORMATION."

The Pottsville formation, or "Pottsville series" or "Pottsville conglomerate," as it has more often been known, is a group of largely arenaceous beds of highly variable thickness which, in eastern Pennsylvania, lies between the Mauch Chunk red shale, or distinctly Lower Carboniferous, and the Lower Productive Coal Measures, or distinctly Upper Carboniferous. Besides the term employed for these terranes in this report, this formation has been otherwise designated the "Seral conglomerate" or "Great conglomerate," by the early Pennsylvania geological survey;[1] the "Pottsville conglomerate," and locally the "Lykens series," by the second geological survey;[2] the "Conglomerate series" by many other geologists;[3] and more recently it has been known in the northern portion of the Appalachian trough as the "Pottsville series," the modified name published by Dr. I. C. White.[4] The early name "Seral" is hardly adaptable to present use, since it was applied by Rogers to the entire Carboniferous series above the red shale in the anthracite region, the lower portion being distinguished from the remainder only by the addition of the word "conglomerate." The claims to consideration of "Great conglomerate" and "Conglomerate series" have been rejected by most geologists, since throughout the greater part of its extent the formation is found to be productively coal-bearing, while in certain districts it contains little or no conglomerate. Nevertheless, the magnificent development of the terranes displayed at Pottsville, which is cited by all authors as the type locality under the various names, and from which the later names "Pottsville conglomerate" and "Pottsville series" were derived, is overwhelmingly conglomeratic, as well as deficient in profitably workable coal. In the various districts of the

[1] Rogers, Geol. Pennsylvania, Vol. I, 1858, pp. vii, 109, 146, 148; Vol. II, Pt. I, pp. 16, 17.

[2] Annual Rept., 1886, Pt. III; Summary Final Report, 1895, Vol. III, Pt. I; Atlas Southern Anthracite Field, Pts. I-VI.

[3] Fontaine, Am. Jour. Sci., 3d series, Vol. VII, 1876, pp. 459, 573.

[4] Bull. U. S. Geol. Survey No. 65, 1891, p. 179.

bituminous basins a number of terms are used for individual terranes or local groups, which have often erroneously and without harmony been correlated with portions of, or with the whole of, the Pottsville formation. The extra-anthracitic nomenclature is not, however, involved in the immediate consideration of the formation in the type region. "Formation" is here used in a broad sense in preference to "series," in view of the subordinate rank of the collective terranes in the geologic column, their biologic unity, and their lack of individual persistence or continuity.

In general, the Pottsville formation has been understood as wholly or in part representing the Millstone grit of Nova Scotia, New Brunswick, and the Old World. This correlation is founded chiefly on the lithologic similarity and the coincidental occurrence of the two formations at the base of the Productive Coal Measures. In the case of the Pottsville the correlation has rested entirely on the order of stratigraphic occurrence and the lithology, a method of coordination that, as will be shown later, has resulted in the reference of a portion of the formation in the Southern States, where it contains the most valuable coals of the Southern Appalachian districts, to the Productive Coal Measures. It has, moreover, been the custom to consider the lithologic representative in each State or region as contemporaneous with and equivalent in toto to the lithologic member or group in every other region, including the type section. The studies, now in progress, of the plant fossils of the terranes in different regions, correlated by lithology with the Pottsville formation, clearly show the fallacy of regarding the lithologic section in each region as covering the same time interval as that covered by every other section. They also show that in certain regions considerable thicknesses of beds which, on account of the lithology, are referred to the post-Pottsville Coal Measures contain the well-marked and distinctly characteristic floras of various horizons in other sections which have been determined, on the lithologic basis, as Pottsville. It is clear that under such circumstances the correlation, especially between separate basins, must be by means of comparative paleontology.

AGENCY OF FOSSIL PLANTS IN THE CORRELATION OF THE TERRANES.

From the foregoing it will be seen that the existing condition is one in which we have, under numerous names, a large number of terranes of supposed Pottsville age in both the interior or Mississippi basin and the eastern basins, the final correlation of which is largely or often wholly dependent on the results of paleontologic study. Since the organic remains in these beds are composed predominantly, if not exclusively, of plant fragments, the foremost questions involved in any correlation with the Pennsylvanian section are: Has the typical Pottsville

formation any reliable and distinct paleontologic characters or aspect? is it satisfactorily distinguishable by means of fossils from the subjacent formations or the overlying Coal Measures? and does the plant life reveal such modifications in time, or such vertical distribution, as to constitute paleontologic subdivisions, zones, or horizons? In answer to these inquiries, it must be confessed that up to the present time nothing has been known of the plants or their associations in the type section. No one appears to have studied the fossils from the Pottsville formation in the vicinity of the type section in the Pottsville Basin, or even in the entire Southern Anthracite coal field. In taking up the task of the stratigraphic elaboration of the Pottsville flora,[1] it was further discovered that neither the upper nor the lower limits of the "Seral" conglomerate, or "Pottsville conglomerate," are closely defined by the earlier geologists, while the somewhat conventional lithologic boundaries proposed in the latest publications on this subject appear to lack general acceptance.

PURPOSE AND SCOPE OF THIS PAPER.

As will have been inferred from the above statements of existing conditions and needs, the purposes of the studies, the immediate results of which are preliminarily reported in this paper, are:

(1) The exploitation and elaboration, from a stratigraphic standpoint, of the plant fossils of the Pottsville formation in the type region in the Southern Anthracite coal field. This involves the voluminous collection of fossils from as many horizons as possible, ranging throughout the entire thickness of the formation, as somewhat uncertainly defined on the lithologic basis.

(2) The critical analysis and comparative study of the plant material collected, with a view to the discovery of the existence of any natural paleontologic subdivisions, zones, or horizons, and their paleontologic characters, or the species of stratigraphic value, if any such are present.

(3) The discovery of the paleontologic limits as differing or as agreeing with the lithologic limits of the type section, and the consequent paleontologic definition of the formation. This entails the examination of the fossils in the terranes below the Pottsville, as well as in the lower portions of the Coal Measures above the lithologic Pottsville, and the determination of (*a*) their relations to the floras of the latter, and (*b*) the significance of those relations in both the geologic and the paleontologic grouping of the formation. Since, as has

[1] Lest the use of the word "paleontology" in this report be considered an unwarranted assumption by those who are accustomed to understanding the term as applying exclusively to animal remains, it should be explained that fossil plants in general are not only most widely distributed and frequently the only fossils in the terranes on the east side of the Appalachian trough, but also that in many of the sections, including the type section at Pottsville, no animal fossils, with the exception of Spirorbis, small, rare, crustacean fragments, and a few cockroach wings, have yet been discovered.

been remarked above, marine animal fossils are very rare in the terranes of the Pottsville along the eastern margin of the trough, the usually abundant plant fossils constitute the chief evidence on which correlations, in this region at least, must be based.

The primary result of this work should be the paleontologic definition, if such is practicable, of the Pottsville formation, and the establishment of a paleontologic section which shall constitute the type section of the formation, for comparison and reference in the study and correlation of other middle Carboniferous phytiferous terranes in the Appalachian province. Two other, largely concomitant, results that are either economic or scientific in their nature have also been reached in the process of the elaboration of the fossil plants of the formation in the typical region. The first, of some economic interest, is the correlation of groups of beds, or of individual coals wrought in disconnected or somewhat isolated portions of the Southern Anthracite field. The other, which concerns the question of general geologic correlation, is the acquisition of data for the determination of the age of the Pottsville formation—i. e., (*a*) the time interval represented by the type section, and (*b*) the equivalents, in a broad sense, of the formation in other basins of this province and in other parts of the world. Incidentally, also, through the discovery in the Pottsville of floras already more or less completely known from isolated and uncorrelated terranes in other regions of the United States, the way is opened to the proper reference and correlation of those terranes with the Pottsville, or with portions thereof. However, in this report no special effort will be made to correlate the formations of this age in the bituminous regions, except in certain special or important cases. Such a work of general correlation will be more naturally and effectively done in connection with a general study of the floras of the supposedly contemporaneous formations in the Appalachian trough and of their relations to the typical Pottsville, a work that of necessity is dependent on and consequent to that now in hand.

In this report the details of the geology of the Southern Anthracite field are considered only to the extent to which they are concerned in the ascertained occurrence, distribution, or relation of the fossils examined. Beyond a general description of the field, the stratigraphic data are largely confined to the orientation of coals or plant beds, or to the definition of the formations in certain sections. The details relating to the areal geology are limited, first, to questions of the area of certain coals as identified and correlated at different points by means of the fossils, and, second, to the correction of certain areal and stratigraphic errors in the existing maps, especially in those relating to the western part of the field. These errors were discovered in the course of paleontologic investigation and were worked out by the combined methods of stratigraphy and paleontology.

GENERAL DESCRIPTION OF THE SOUTHERN FIELD.

FORM AND EXTENT OF THE FIELD.

The Southern Anthracite field, known also as the Schuylkill or Pottsville, and as the First Anthracite field, is, as its name implies, the most southern of the four fields or regions into which the anthracite basins of Pennsylvania group themselves. It embraces an area of about 181 square miles, lying in Carbon, Schuylkill, Lebanon, and Dauphin counties. Its territory is mapped on the Hazleton, Mahanoy, Pottsville, Catawissa, Shamokin, Lykens, Hummelstown, and Harrisburg sheets of the Topographic Atlas of the United States. Its greatest longitudinal extent is a little over 70 miles, from the Lehigh River at Mauch Chunk, in a direction averaging nearly S. 60° W., to within 1½ miles of the Susquehanna River at Dauphin, 8 miles north of Harrisburg. Its maximum breadth is nearly 8 miles, from the crest of Sharp Mountain across Broad Mountain, in the region west of Pottsville. Eastward the field narrows to a width of about 2 miles at Tuscarora, whence it extends, between Sharp Mountain on the south and Locust Mountain on the north, in a linear-lanceolate prolongation, hardly exceeding 2¼ miles in width, to the Lehigh River. Owing to the structure, the margin on the northwest, in the central portion of the field, is cut in rounded westward-projecting lobes of Broad Mountain, so that at a point a short distance west of Tremont, or about 12 miles west of Pottsville, the field is reduced to a width of 4 miles. From this point the north and south borders diverge at an angle of about 20°. At the same time a very extensive arch, the Perry County anticline, penetrates the field from the west, causing the parting of the latter, as far as a point about 4 miles west of Tremont, into two narrow divergent arms or prongs, forming what is known as the "fish tail" of the Southern Anthracite field. The northern of these prongs, the Wiconisco Basin, lying between Bear and Big Lick mountains, is about 16 miles long, 2 miles in greatest breadth, and ends in a rather blunt point about 3 miles west of Lykens. The other prong, which also is about 2 miles wide at the base, and which tapers gradually from the latter for 30 miles to near the Susquehanna River, is known as the Dauphin Basin. It is bounded by Sharp Mountain on the south and by Stony Mountain on the north.

GENERAL GEOLOGIC STRUCTURE.

Structurally, the Southern field is a synclinorium—a complicated group of synclines producing a great and, at points, irregular basin. Besides the numerous principal axes of folding, which are conformable with the usual Appalachian trend, there are other oblique, more nearly due east-west undulations, which have had much to do with

the delimitation of the fields in their entirety, as well as in complicating the minor structure of the basins. The general geologic features of the region are shown in the large geologic map of the State, published in 1893, and in the county maps accompanying the descriptive reports of the second geological survey of the State. The relation of this region to the other anthracite regions is illustrated in the new General Map of the Anthracite Region, revised to 1890, published separately by the survey in reduced form, as one of the miscellaneous maps in Pt. I of the Atlas of the Southern Anthracite Field. The geology of the Southern field in particular has been worked out at great pains and expense by the late geological survey of Pennsylvania. The six parts or volumes, with two supplements, comprising the Atlas of this field, in which are presented in great detail the mine workings and the areal geology, on a scale of 800 feet to the inch; numerous cross sections, mostly on a scale of 400 feet to the inch, and a great number of columnar sections, chiefly at a unit of 40 feet to the inch, represent the latest and most experienced work of the survey. Notwithstanding the fact that the field methods were of necessity developed in the course of the work in order to meet existing conditions, and the presence of many errors in correlation, the Atlas of the Southern Anthracite Field in Pennsylvania represents the most minutely detailed and most excellent economic work on sedimentary deposits that has yet been accomplished over an extensive area in this country. To the abundant mine maps, profiles, and sections therein contained reference will frequently be made. Wherever the work here reported results in additions or corrections to the State mine maps, they will be so described that the changes or additional matter can in most cases be readily applied. The flexures of the field, which offer a most interesting study, were described at considerable length by H. D. Rogers in the Geology of Pennsylvania. The geographic features of the basin are incompletely represented in Pl. CLXXX of this report, which is here presented as an index to the State maps, as well as for the purpose of indicating the localities at which fossils have been collected.

On examining the maps referred to above, it will be noted that in general the folding of the strata is closer toward the southern border of the field and more open to the north. Thus the southern limit of the basin, along Sharp Mountain, is somewhat overturned throughout the greater part of its length, while in the widest part of the basin, near the northern border, the undulation of the beds is comparatively gentle. To this is possibly due the variable and interesting topography of the district; for where the strata are more steeply inclined the ridges caused by the erosion of the soft shales on either side of a hard formation are narrow and sharp, while the hard terranes, when but slightly flexed and nearly horizontal, form the resist-

ant floor of a high plateau. Along the southern border of the coal field we accordingly find that the upturned and nearly vertical hard beds of the Pottsville formation compose the crest of a narrow mountain, Sharp Mountain, between which and the upturned wall of the Pocono (Vespertine, X), the basal member of the Eocarboniferous in the Second Mountain, extends a narrow parallel valley cut in the likewise upturned soft red shales of the Mauch Chunk formation (Umbral shale, XI), which, in the Schuylkill region, reaches its maximum thickness of over 3,000 feet. The steep inclination of the Pottsville floor is similarly accountable for the rigid and cristate character of the rim of the coal field in Sharp Mountain, in Stony or Fourth Mountain on the north side of the Dauphin Basin, in Bear and Wiconisco mountains in the northern prong of the "fish-tail," and in Locust Mountain. Its more enduring composition, as compared with the terranes of the Coal Measures, has resulted in the erosion of irregular valleys, generally corresponding to the axes of the basins. Throughout the Southern Anthracite field, wherever the elevation of the Pottsville has been sufficient to cause its complete erosion, the consequent erosion of the underlying Mauch Chunk shales has been so rapid as to form sharply defined valleys, varying in width according to the area uncovered or the inclination of the beds. It thus happens that Broad Mountain, on which is spread the northern dilation of the coal field, comprises essentially an elevated undulating plateau sustained by the rigid, flexuous Pottsville floor of the Coal Measures, which here, as in the Coal Measures of the other anthracite fields, prevailingly forms anticlinal ridges and synclinal valleys. The breaking through of the Pottsville on the anticlinal axes along the western portion of Broad Mountain is responsible for the deep cove-like valleys between the lobes of the field, as noted above, the borders being often formed by massive cliffs of the gently inclined Pottsville conglomerates. In the region north of Pottsville the elevated Pottsville formation is not entirely cut across at any point, the result being that there is a continuity of the conglomerates, which bridge the axis from the New Boston Basin into the Mahanoy Basin of the Western Middle Anthracite field. The line of division between these fields, which, as may be inferred, is somewhat conventional, is drawn along the axis south of the northward plunge of the conglomerates into the Mahanoy Basin.

The irregularity of the margin of the Southern coal field along Broad Mountain is quite in contrast with the relatively straight borders of the prongs of the "fish tail," or of the southern margin of the field along Sharp Mountain from the Susquehanna River to a point east of Middleport. This condition is largely due to the closer folding and increased depth of the Coal Measures toward the south, so that the soft shales beneath the Pottsville are not brought to light by the minor flexures. The effect of the latter is, however, evident

along the border of the field, in the scallops at the west extremity of the Wiconisco Basin and in the angle of the "fish tail" west of Tremont, while it also appears in Sharp Mountain itself east of Middleport, and in the Summit Hill district. The occurrence of another lobe of the field along the apparently rigid Sharp Mountain, in the region of Lorberry Gap, seems only to have been escaped by an overthrust fault of the basal portion of the Coal Measures, as will be shown in a later portion of this report.

DESCRIPTION OF THE POTTSVILLE FORMATION IN THE TYPE REGION.

As has already been remarked, the Pottsville formation is, in the type region, composed chiefly of massive siliceous conglomerates. It will be seen later, in the course of a comparison of various sections, that this topographically conspicuous formation, which constitutes the floor of the Coal Measures, comprises a series of ponderous conglomerates, which are more variable in color, composition, and assortment in the lower part, and more quartzose, dense, and light colored near the top. These conglomerates alternate near the base with washes of purple and olive mud or soft, greenish sandstone, and in the higher portion with thin beds of arenaceous shale, and are interspersed with a number of carbonaceous beds, some of which, in portions of the field, are workable over considerable areas, their product being the most valuable of the anthracite coals.

The formation, as a whole, varies greatly in thickness, the maximum of a little more than 1,200 feet being reached in the vicinity and to the west of the type section, east of which it thins remarkably. That it thins toward the west in the Southern field itself has more recently been doubted. It is clear, however, that the relative thickness of its divisions is quite different in some of the sections, if the total depth remains the same. The sandstones, like the coals, are extremely variable even within short distances.[1] Northwestward the formation thins rapidly in the anthracite regions, its development being about 850 feet in the Shamokin district of the Western Middle field, or an average of about 350 feet in the Eastern Middle field, while it is recorded as averaging 225 feet in the Northern Anthracite field.

In the Southern Anthracite field, the formation is apparently conformable with the Mauch Chunk shales, while the line of separation between it and the superimposed Coal Measures, which are also highly arenaceous, abounding in conglomerates, has for convenience been drawn at the lowest workable coal in the type region.

[1] Compare columnar sections on columnar-section sheet xi, Pl. IV B of the Atlas of the Southern Anthracite Field.

COMPOSITION OF THE FORMATION.

The character and composition of the Pottsville formation and its relation to the Umbral shale (Mauch Chunk formation) below and the Productive Coal Measures above are well shown in the magnificent exposure in the cutting along the Pennsylvania Railroad through Sharp Mountain on the east side of the gap below Pottsville. A somewhat detailed section of this exposure, extending from Tumbling Run Valley to the Pottsville Valley is given on Pls. CLXXXI, CLXXXII. This section includes the upper portion of the Mauch Chunk red shales and extends to the Dirt bed, the third workable coal of the Coal Measures at this point. The Pottsville formation itself may, for the present, be considered as comprising that portion, nearly 1,200 feet in thickness, of the section between the topmost bed of red shale and the "Twin" coal, which in both the first and the second geological surveys of this State has been agreed upon as the boundary between the Pottsville formation and the succeeding Lower Coal Measures.

On referring to the section it will be observed that the lower portion represents a transition from the typical red, purplish-red, and olive-green shales of the Mauch Chunk to the almost exclusively arenaceous, ponderous quartz-conglomeratic terranes of the Pottsville formation. The conglomerates intercalated in increasing proportions in the upper beds of the Mauch Chunk consist of irregularly bedded, poorly assorted, or sometimes apparently unassorted pebble or bowlder accumulations in a matrix of coarse arkose sands colored by reddish or greenish shale washes. The pebbles are mostly of quartz, though sandstone, syenite, chloritic schist, limestone, and even red and green shales and conglomerate fragments are also present. Occasionally the pebbles, which are sometimes subangular, attain a diameter of 3 or 4 inches or more; but in most of the beds the coarsest materials do not exceed a goose egg in size. For a long distance from the base of the formation the conglomerate matrix consists of a micaceous, chiefly arenaceous medium, poorly cemented and often colored with a red or green argillaceous material.

In passing upward the beds of red shale are less conspicuous, and at about 1,200 feet below the Twin bed the last distinct stratum of typical Mauch Chunk red shale is seen. Above this the conglomeratic matter prevails almost exclusively through a long interval. Nevertheless, the olive-green shales occur here and there throughout an interval extending 200 or 300 feet higher, while most of the conglomerates in the lower portion of the section derive their color from the greenish or reddish mingled sediments. The irregular bedding and the variety of the rock materials in the pebbles, which are often imperfectly rounded, are interesting features of the lower portion of the Pottsville formation itself. This portion of the section is notably characterized by

the occurrence of olive-green or slightly reddish mud beds, apparently redeposited from the older formation. These muds often conclude rapid transitions from greenish conglomeratic sandstones into fine argillaceous silts of no great thickness. On the conspicuously uneven surfaces of the latter, coarse conglomeratic strata or typical bowlder beds are directly imposed, in knife-edge contacts, at a number of horizons in the lower half of the section. These irregular, intercalated muds, which are similar to others in the upper part of the Mauch Chunk formation, sometimes appear as thin lenses interspersed among the irregular layers of the conglomerates. Without further detailed description of the type section, for which the reader is referred to Pls. CLXXXI, CLXXXII, it will appear that we have a series of beds of passage—i. e., a transition series—consisting of coarse, heterogeneous, semiassorted, conglomeratic materials, intercalated in the uppermost beds of red shale, above which, for a distance of several hundred feet, many of the conglomerates preserve essentially the same characters, although typical deposits of the red and green shales are wanting. Subangular pebbles in imperfectly bedded arkose conglomerates are not rare throughout the lowest third of the formation in this vicinity. Although the quartz material preponderates, pebbles of sandstone and shale are not infrequent. Occasionally some of the pebbles attain the proportions of goose eggs, and farther east, in a section near the Hacklebarney tunnel, some of them measure 5 to 6 inches in diameter.

As already indicated, the conglomerates in the lower portion of the Pottsville formation are prevailingly greenish, arkose, and poorly cemented. Usually, in the more freshly cut sections, they offer little resistance, and frequently they are but slightly displayed. When, however, the erosion has been very slow, as along the summit of Sharp Mountain, the ferruginous material so cements the pebbles that the lower ledges of the formation often predominate and form, for considerable distances, the crest of the mountain. This feature is more noticeable to the eastward of Swatara Gap. In the upper half of the formation the conglomerates become more rigid, more distinctly arenaceous, and more persistent, the pebbles being better rounded, more compactly disposed, and regularly assorted. Sandstone without pebbles is rare and is always thin in the section. Cross bedding, indicative of current movement from the northeast, is conspicuous. In the more shaly conglomeratic sandstones in the middle of the section concretionary weathering is especially noticeable.

Generally speaking, the relatively small amount of shales and of coaly matter in the type section is, for the most part, contained in the middle third. Toward the top the conglomeratic material becomes lighter colored, as well as more exclusive, and at a distance of 200 or 300 feet below the Twin coal, in that portion of the exposure opposite the

Pennsylvania Railroad bridge, occur the most massive, rigid, densely quartzitic, regularly bedded, and persistent conglomerates of the entire section. These conglomerates constitute a close group or plexus of ponderous ledges in which the formation culminates. They usually form the conspicuous beds in every exposure of the formation, and in every break in Sharp Mountain through which the waters of the basin find escape these steeply inclined ledges appear as jagged, irregular teeth, picturesquely defining the jaws of the gap. Exceptions to this, however, are Lorberry and Fishing Creek gaps, at which the entire Pottsville formation appears to be absent. Usually they also form the crest of the mountain, although, as was remarked above, the lower conglomerates predominate in the older exposures. It may be noted in this place that these uppermost white or light-gray conglomerate plates, which in both their lithologic and their paleontologic characters are distinctly comparable to the Homewood sandstone in the bituminous basins, appear to have the greatest geographic extent and regularity of all the strata in the formation. They are among the few individual beds which, although varying in thickness and in relative intervals, may be traced to sections in distant portions of the same field.

As shown in Pls. CLXXXI, CLXXXII, the type exposure at Pottsville exhibits a number of thin coals, none of which are profitably workable in this vicinity, although most of them have been diligently prospected. The exposure nearly 800 feet below the Twin bed appears to have been followed by a drift for some distance above the wagon road on the east side of the gap, while another coal, about 400 feet below the Twin, has been somewhat extensively tested, not only farther north in the same gap, but at two or more levels in the gap at Westwood. The consideration of the approximate and comparative age of some of these coals, with reference to the productive coals toward the western end of the field, will be continued in connection with the discussion of the fossil plants of the various horizons. Plant collections have been made from eleven different horizons, marked A–N in the section, as well as from the roof of the Twin coal, marked O.

Other published sections excellently illustrating the lithology of the Pottsville formation in the Southern Anthracite field are those at Hacklebarney,[1] Nesquehoning Gap,[2] and Locust Gap at Tamaqua,[3] in the region east of Pottsville. The character of the sedimentation in the region north of Pottsville is shown by the records of the diamond-drill bore holes near the Altamont colleries, throughout a distance of 5 or 6 miles along Broad Mountain.[4] The composition of the

[1] Atlas Southern Anthracite Field, Pt. I, mine sheet i, cross-section sheet i, columnar-section sheet i, section 4.

[2] Idem, Pt. I, mine sheet ii, columnar-section sheet ii, cross-section sheet ii.

[3] Idem, Pt. I, mine sheets iii and iv, columnar-section sheet ii, cross-section sheet iii, section 39, profile 12.

[4] Idem, Pt. IV, columnar-section sheet ix, sections 1–6.

beds in the western part of the field is well shown in the sections at Lincoln,[1] Kalmia,[2] and Lykens.[3] Portions of the first two named are reproduced in Pls. CLXXXIII and CLXXXIV of this report, in illustration of the formation in the Lincoln mining region.

CONGLOMERATIC NATURE OF THE COAL MEASURES.

It may be remarked in this place that throughout the Southern Anthracite field the Lower Coal Measures also are largely conglomeratic. Frequently these conglomerates rival in size and rigidity individual beds of the Pottsville formation itself. Illustrations of the proportions of conglomeratic material, which in some cases constitutes nearly a third or more of the section, are found in columnar-section sheets i and vi, in Pts. I and II, respectively, of the Atlas of the Southern Anthracite Field; or in the sections at the tunnels in Wood's colliery and Dundas No. 6 colliery, at the north base of Sharp Mountain, between Pottsville and Tremont, shown in columnar-section sheet viii, Pt. IV of the Atlas. The same character is still better presented in the regions north and west of Tremont, the sections of which are given in columnar-section sheet x, Pt. IV B of the Atlas.

THE LYKENS OR POTTSVILLE COALS.

It will be observed that in the section of the Pottsville formation at the gap south of Pottsville a number of thin coals are present, several of them having been prospected in the vicinity of the typical locality. Coals are to be found in varying numbers in every complete section of the formation, though in the neighborhood of the type section they have not proved to be of profitable thickness. However, to the north of Pottsville, on Broad Mountain, and to the west, throughout the Southern field, coals occur in greater development, especially locally, and have been extensively mined. Reference to several detached or somewhat isolated mines in those coals will again be made in connection with the consideration of the distribution of the fossil plants and the correlation of the coals. These coals of the Pottsville formation, which are commercially known as the "Lykens" coals, and which comprise the "Lower Red Ash" groups of the Southern field, appear to be best developed or most advantageously exploited in the districts west of Tremont, including the Lincoln region and the Wiconisco Basin.

In the anthracite fields, as well as in other coal fields of the Appalachian trough, the combustible of the Pottsville formation is generally

[1] Atlas Southern Anthracite Field, Pt. III, mine sheet xvii; Pt. IV B, columnar-section sheet xi; Pt. V, cross-section sheet xvii, section 21.

[2] Idem, Pt. III, mine sheets xxi and xxii; Pt. IV B, columnar-section sheet xi, columnar sections 10, 11, and 12; Pt. VI, cross-section sheets xxi, section 29.

[3] Idem, Pt. III, mine sheet xx; Pt. IV, columnar-section sheet vii, columnar sections 9, 10, 11 and 12; Pt. VI, cross-section sheet xx, section 28.

the most valuable of the entire series of Carboniferous coals; for, while as individual beds the Pottsville coals may be inferior in thickness and areal extent, their superior qualities create for them the highest demand and encourage their production even under conditions entirely unfavorable for the exploitation of other and thicker beds. To this formation belong the Sharon coal of northern Ohio and northwestern Pennsylvania; the Pocahontas and New River coals of Virginia and West Virginia, celebrated as steam and coking coals; the chief coal horizons of eastern Tennessee; the coals of Georgia; and the principal furnace and steam coals of Alabama. The special fitness for domestic use of the rather free-burning Lykens coals, which wins for them an advance of from 25 cents to $1.25 per ton over the prices of other coals of the anthracite series, has resulted in the establishment in the Lincoln-Lykens region of several of the largest mining plants in the anthracite fields, the capacity of the Lincoln and Brookside collieries,[1] which are exclusively occupied with the Lykens coals, being 2,900 tons a day of ten hours.

For a long time it was supposed that the Lykens coals were of the age of the Productive Coal Measures, the supra Pottsville series, but later and more systematic stratigraphic work has shown them to be distributed through the Pottsville formation itself. It requires but a glance at the plant fossils of these coals to detect their antiquity as compared with those of the coals of the higher formation.

Like the other members of the formation, the coals are exceedingly variable in thickness, often attaining a remarkable local development, though east of the Lincoln region they seldom reach a workable thickness except in isolated and restricted areas. Nevertheless, one of the lower coals appears to extend over a considerable territory in Broad Mountain, where it has been worked at a number of points, and whence it may be traced over the narrow arch into the Shamokin region of the Western Middle Anthracite field. The coals have been tested at many points to the eastward. One of the beds is still worked in a mine operated by Mr. Isaac Christ on the east side of Locust Gap, at Tamaqua, while the fossils obtained from a drift lately opened near the head of the incline on Mount Pisgah, at Mauch Chunk, show the coal to lie relatively high in the Pottsville. In the Dauphin Basin, westward from Rausch Gap and the Lincoln region, the Lykens coals are not worked at present. The basin, the central portion of which was extensively prospected in the early half of the century, has long been abandoned, for the reason that in passing westward the coals opened were found to be soft, crushed, semibituminous, and of generally inferior quality.

[1] Analyses of the West Brookside coals made by Dr. Cresson in 1879 show: Volatile matter, 5.4 per cent; ash, 8.78 per cent; sulphur, 0.36 per cent; phosphorus, none; fixed carbon, 85.636 per cent.

It will be shown in this report that the exploitations and provings on which was based the conclusion that the Lykens coals were of inferior quality or worthless in the Dauphin Basin were, in fact, confined to the softer and inferior coals of the Productive Coal Measures, in the interior of the basin. These coals are not in the Pottsville formation. All the coals mapped by the State geologist as "Lykens" throughout the greater part of the southern limb of that basin, including practically all the early developments east of the Big Flats, are, in fact, within the Productive Coal Measures. The entire Pottsville formation, with its scarcely prospected Lykens coals, not only lies to the south of the supposed approximate boundary of the "lowest Lykens coal," but a large portion of its steeply inclined terranes, including the lowest Lykens coals, outcrops for nearly a score of miles along a zone represented as red shale on the mine sheets.

NOMENCLATURE OF THE COALS.

It is uncertain how many of the Lykens (Pottsville) coals are at one place or another workable, since some of them are evidently too thin for profitable mining in each of the mine sections. Certain of the sections may show as many as a dozen or more thin coals or coaly partings, but it is not probable that more than eight or nine at most are anywhere worked, and it is only in a few cases that as many as five coals in this formation can be productively worked at one locality. Usually not more than three are profitably mined at one point.

The number of the principal workable coals and their relative positions are best revealed at the Lincoln mines and in the Brookside-Lykens district, which is essentially continuous to the westward of the former. At the Lincoln mines, where the upper Lykens coals are best displayed, six coals are or have been worked. The columnar sections, earlier mine maps, and profiles of these mines are shown in mine sheets xvii to xxi, Atlas Southern Anthracite Field, Pt. III; columnar-section sheets vii and xi, Atlas Southern Anthracite Field, Pt. IV; and cross-section sheets xvii to xxi, Atlas Southern Anthracite Field, Pt. V. In several of the sections the Lykens No. 1 coal is shown at about 210 feet below the coal identified by the State geologist as the Buck Mountain bed, as at Good Spring, or at about 250 feet below a bed presumably the same, as at the Lincoln mine. (See Pl. CLXXXIII.)

Lykens coal No. 1½, formerly worked at the New Lincoln mine, is platted at approximately 240 feet below Lykens coal No. 1; while Lykens coal No 2 in the same mine is but 78 feet below the latter in the second lift tunnel. At this point Lykens coal No. 3, which at other points may diverge as much as 30 feet or more from No. 2, is separated from the latter by only 3 inches of dirt. Lykens coal No. 4, locally known as "White's bed," is about 245 feet below No. 3 at Lincoln. Lykens coal No. 5, the "Lykens Valley" bed, or, as it is also locally

called, the "Big bed," is about 115 feet below coal No. 3 in the Lincoln tunnels, though the interval is 140 feet in the large tunnel at Williamstown. A thinner and less extensive coal, Lykens No. 6, or the "little bed," lies about 48 feet below No. 5 in the vicinity of the Lincoln mine, though at Williamstown the interval is over 65 feet. None of the upper Lykens coals, Nos. 1–3, are worked in the Wiconisco Basin, unless it be at Kohler's Gap, north of Brookside, where a coal, supposed to be Lykens bed No. 3, is dug for local use.

At the Brookside, Williamstown, and Short Mountain collieries only the lower coals (Nos. 4, 5, and 6) are worked, except at Williamstown, where a rather thin coal, the Zero bed, the thickness of which is given as 3 feet in the published section (columnar-section sheet vii, Atlas Southern Anthracite Field, Pt. IV), has been developed at 37 feet 7 inches below coal No. 6. This bed, if present at all in the Kalmia section, must be represented by only 6 inches of coal, but 5 feet 3 inches below the Lykens coal No. 6. The nomenclature of the coals given above is that employed by the Philadelphia and Reading Coal and Iron Company and adopted by the late State geological survey. In the vicinity of Lykens the coals were formerly numbered from the base upward in an opposite direction, and they are so designated in Rogers's discussion of this field in the Geology of Pennsylvania.

The above statements of the intervals between the coals are given as typical, without reference to the remarkable variation in the intervals as ascertained by the underground connections from mine to mine. The matter of this variation, as well as the stratigraphic position of the coals on Broad Mountain and in other portions of the field, will be touched upon when considering the thickness of the Pottsville formation and the evidence of the plants as to the correlation of the beds. For information as to the thickness of the coals the reader is referred to the State publications cited above, or to the typical section reproduced in Pls. CLXXXIII and CLXXXIV.

THE TYPE PALEOBOTANIC SECTION OF THE POTTSVILLE FORMATION.

FOSSIL-PLANT COLLECTIONS.

In the Southern Anthracite field fossil plants have been collected at 41 localities, from the Pottsville formation, or from the roof of the coal supposed to form the dividing line between the Pottsville formation and the overlying Productive Coal Measures. These may be grouped as follows:

1. Lower Lykens coals at Miller's drifts,[1] Big Run,[2] Wiconisco,[3] Big

[1] Pl. CLXXX, station 14. Atlas Southern Anthracite Field, Pt. III, mine sheet xx.
[2] Pl. CLXXX, station 13. Atlas Southern Anthracite Field, Pt. III, mine sheet xx.
[3] Pl. CLXXX, station 12. Atlas Southern Anthracite Field, Pt. III, mine sheet xx.

Lick,[1] Williamstown,[2] Brookside,[3] and East Brookside in the Wiconisco Basin; and from Kalmia,[4] Lincoln,[5] Rausch Gap (Pl. CLXXXV) Schuylkill County,[6] and Swatara Gap[7] of Sharp Mountain, in the Lincoln district.

2. Upper Lykens coals at Lincoln colliery, New Lincoln,[8] the North Brookside slope near Good Spring,[9] and the lower Eureka tunnel north of the old Colket mine.[10]

3. A third category, including detached points, or beds whose relations to the individual Lykens coals are subject to doubt, embraces collections from Kohlers Gap,[11] a shaft near the North Brookside slope, the upper Eureka tunnel, a prospect shaft near the mouth of the latter, the Kemble drift,[12] Altamont colliery No. 1,[13] two levels in the gap at Westwood,[14] the drift in Mount Pisgah,[15] and 12 levels in the type section at the Pottsville Gap.[16]

4. The collections from various levels at Lorberry Gap,[17] Fishing Creek,[18] Black Spring Gap (Mount Eagle),[19] Gold Mine Gap,[20] Rausch Gap (Lebanon County),[21] Yellow Springs Gap,[22] Rattling Run Gap,[23]

[1] Pl. CLXXX, station 11. Atlas Southern Anthracite Field, Pt. III, mine sheet xix; Pt. VI, cross-section sheet xx.

[2] Pl. CLXXX, station 10. Atlas Southern Anthracite Field, Pt. III, mine sheet xix; Pt. IV, columnar-section sheet vii, section 8; Pt. VI, cross-section sheet xx, section 27.

[3] Pl. CLXXX, station 9. Atlas Southern Anthracite Field, Pt. III, mine sheet xviii; Pt. VI, cross-section sheet xix, section 26.

[4] Pl. CLXXX, station 41. Atlas Southern Anthracite Field, Pt. III, mine sheets xxi and xxii; Pt. IV B, columnar-section sheet xi, sections 10, 11, and 12; Pt. VI, cross-section sheet xxi, section 29.

[5] Pl. CLXXX, station 5. Atlas Southern Anthracite Field, Pt. III, mine sheets xvii and xxi; Pt. IV B, columnar-section sheet xi, sections 8–9; Pt. VI, cross-section sheet xvii, cross section 24.

[6] Pl. CLXXX, station 4. Atlas Southern Anthracite Field, Pt. III, mine sheet xvi.

[7] Pl. CLXXX, station 3. Atlas Southern Anthracite Field, Pt. III, mine sheet xvi.

[8] Pl. CLXXX, station 6. Atlas Southern Anthracite Field, Pt. III, mine sheet xvii; Pt. IV, columnar-section sheet vii, section 4; Pt. V, cross-section sheet xviii, section 24.

[9] Pl. CLXXX, station 7. Atlas Southern Anthracite Field, Pt. III, mine sheet xvii; Pt. IV B, columnar-section sheet x, section 8; Pt. VI, cross-section sheet xix, section 25.

[10] Pl. CLXXX, station 33. Atlas Southern Anthracite Field, Pt. III, mine sheet xvi; Pt. IV B, columnar-section sheet x, section 6; Pt. VI, cross-section sheet xvii, section 23.

[11] Pl. CLXXX, station 15. Atlas Southern Anthracite Field, Pt. III, mine sheet xviii; Pt. VI, cross-section sheet xix, section 26.

[12] Pl. CLXXX, station 16. Atlas Southern Anthracite Field, Pt. II, mine sheet xiii; Pt. V, cross-section sheet xviii, section 23.

[13] Pl. CLXXX, station 36. Atlas Southern Anthracite Field, Pt. II, mine sheet vii; Pt. IV, columnar-section sheet ix, section 1; Pt. V, cross-section sheet v, sections 16 and 17.

[14] Pl. CLXXX, station 2. Atlas Southern Anthracite Field, Pt. II, mine sheet xiv; Pt. IV B, columnar-section sheet xi, section 5; Pt. VI, cross-section sheet xii, section 19.

[15] Pl. CLXXX, station 40. Atlas Southern Anthracite Field, Pt. I, mine sheet i, cross-section sheet i, section 1.

[16] Pl. CLXXX, station 1. Atlas Southern Anthracite Field, Pt. III B, mine sheets xiv and xiva; Pt. IV, columnar-section sheet viii, section 3; Pt. V, cross-section sheet viii, section 17.

[17] Pl. CLXXX, station 17; Pl. CLXXXV, Fig. 1. Atlas Southern Anthracite Field, Pt. III, mine sheet xxi; Pt. VI, cross-section sheet xvi, section 24.

[18] Pl. CLXXX, station 18; Pl. CLXXXVI, Fig. 1. Atlas Southern Anthracite Field, Pt. III, mine sheet xxi.

[19] Pl. CLXXX, station 19; Pl. CLXXXVI, Fig. 2. Atlas Southern Anthracite Field, Pt. III, mine sheet xxi.

[20] Pl. CLXXX, station 20; Pl. CLXXXVI, Fig. 3; Pl. CLXXXVII, Fig. 1. Atlas Southern Anthracite Field, Pt. III, mine sheet xxii; Pt. IV, columnar-section sheet viii, section 7; Pt. VI, cross-section sheet xxi, section 29.

[21] Pl. CLXXX, station 21; Pl. CLXXXVII, Fig. 2. Atlas Southern Anthracite Field, Pt. III, mine sheet xxiii; Pt. IV, columnar-section sheet viii, section 9; Pt. VI, cross-section sheet xxi, section 30.

[22] Pl. CLXXX, station 23. Atlas Southern Anthracite Field, Pt. III, mine sheet xxiv; Pt. IV, cross-section sheet xxi, section 31.

[23] Pl. CLXXX, station 24. Atlas Southern Anthracite Field, Pt. III, mine sheet xxv; Pt. IV, columnar-section sheet viii, section 10.

Big Flats[1] north of Watertank Station, Fort Lookout,[2] and a number of the old drifts [3]to the westward, made in the early part of the century, will be considered in connection with the special discussion of the Dauphin Basin.

5. The fifth category includes plants from the "Buck Mountain" coal or a coal (the Twin coal) supposed to be its equivalent at Swatara Gap at Middle Creek,[4] Ebony colliery[5] north of Newcastle, Altamont colliery No. 2,[6] Locust Mountain and Sharp Mountain gaps,[7] near Tamaqua, and at the Pottsville Gap.

SPECIES AND THEIR OBSERVED DISTRIBUTION WITHIN THE FORMATION AND FIELD.

In order to avoid the repetition of names which would result from an enumeration of the species from each locality or bed, the plants from the Pottsville formation in the region of Pottsville and westward in the Southern Anthracite field, exclusive of the Dauphin Basin, will be combined in one list, with a table showing their distribution so far as yet observed in that formation. Since the economic interest of the problem of stratigraphic paleontology centers primarily about the Lykens coals, the localities affording plants from the roof shales directly in connection with these coals, as definitely correlated between the large mines, are placed first. From an economic standpoint they constitute a typical paleontologic representation of the productive coal-bearing horizons, just as the Pottsville Gap section affords a typical paleontologic section of the formation as a whole. Since, also, it is at once clear that the species commonly in association with the lower Lykens coals are largely different from those over the upper Lykens coals, the principal coals of the mining region are naturally divided paleobotanically into two groups: An upper group, including coals 1–3, and a lower group, containing Lykens coal No. 4 and the remaining lower portion of the formation.

For the sake of easier comparison, the plant-bearing horizons A–M,[8] in ascending order, in the Pottsville Gap section, are placed next. To the right of these are a number of columns representing isolated developments of supposed Lower Lykens age; and beyond these are a few

[1] Pl. CLXXX, station 26. Atlas Southern Anthracite Field, Pt. III, mine sheet xxvi.

[2] Pl. CLXXX, station 27. Atlas Southern Anthracite Field, Pt. III, mine sheet xxvi; Pt. VI, columnar-section sheet viii, section 11; Pt. III, mine sheet xxvi.

[3] Pl. CLXXX, stations 28–32. Atlas Southern Anthracite Field, Pt. III, mine sheets xxvi and xxvii.

[4] Pl. CLXXX, station 34. Atlas Southern Anthracite Field, Pt. II, mine sheet xiii; Pt. IV B, columnar-section sheet x, section 4; Pt. VI, cross-section sheet xiii, section 22.

[5] Pl. CLXXX, station 35. Atlas Southern Anthracite Field, Pt. II, mine sheet vi; Pt. V, cross-section sheets v–viii, section 17.

[6] Pl. CLXXX, station 37. Atlas Southern Anthracite Field, Pt. II, mine sheet vi; Pt. IV, columnar-section sheet ix; Pt. V, cross-section sheet viii, section 16.

[7] Pl. CLXXX, stations 38 and 39. Atlas Southern Anthracite Field, Pt. I, mine sheet iii, cross-section sheet iii, section 12, columnar-section sheet iii; Pt. II, mine sheet iv.

[8] The application of letters to the plant beds of the type section is only for convenience of reference in this report. The letters are not introduced in the nomenclatural sense, and are not intended for permanent use. They are, therefore, not to be confused with the nomenclature of the coals in the Panther Creek Basin or other portions of the anthracite regions.

localities apparently referable to the Upper Lykens group. To make clear the paleontologic significance of this division, the species are systematically grouped in two sections, the first including those observed in the Lower Lykens division, the other containing the remainder of the species.

Generally speaking, the collection of plants in the Pottsville formation is more difficult than in the succeeding Coal Measures, not only on account of the frequent occurrence of conglomeratic sandstone in the roof of the coals, but also on account of the usually fragmentary condition of the vegetable material, which prevailingly seems to have suffered severely, as might be expected from the composition of the environing terranes, through the exigencies of driftage. As is natural, the larger collections, containing the greater proportion of the species, were obtained from the rock dumps at the collieries, or from the more propitious plant beds in the gap sections, while the material from beds in which fossils are very scarce or poorly preserved is, in spite of considerable persistence in collection, often conspicuously scant. It thus happens that some of the examples from a bed are too fragmentary for certain specific identification with remains found elsewhere; and the presence of the species at these localities is, accordingly, doubtful and indicated by a query. Another difficulty affecting the stratigraphic reference of the species arises from the collection of large quantities of material, including the best fossils, from mine dumps receiving the roof shales from two or more coals, so that it was at first found impossible to ascertain from which of the coals a given fossil was derived. However, by a painstaking study of the plants and their associations on slabs obtained from definitely fixed beds at other points, or procured through the unfailing courtesy of the local engineers, superintendents, and mine foremen, directly from the interior of the mines, it later became possible to assign much of the material from the rock dumps, either definitely or approximately, to their original sources. Such references, made with great caution, are indicated in the respective columns by numbers referring to the coal from whose roof the specific fossil came.

A discussion of the significance of the composition of the flora and the range of the species will receive attention in connection with the subject of the age and equivalents of the formation. Economy of space forbids the description of the species in this report. Many of them are new, while many others have been the subject of careful revision. A few only will here receive any systematic biologic treatment. The descriptions of all the material in hand are now complete, and will form part of a monograph, in process of preparation, on the flora of the Pottsville formation in the Appalachian province. Their present publication would therefore lead to duplication.

PALEONTOLOGIC DIVISIONS OF THE FORMATION.

An inspection of the table (p. 776) showing the distribution of the plants within the Pottsville formation itself in the Southern Anthracite field shows that the species are essentially divided into two groups, one of which is confined to the lower Lykens coals, or the lower part of the formation, the other being present in the upper Lykens coals, and the upper beds of the formation as a whole. For convenience in reference all the plants occurring at any point in the Lower Lykens group of coals are placed in the first list. It is not impossible that a number of these will eventually be found in the upper division of the formation. However, so far as my observation has gone, it appears that, except among the gymnosperms, but 3 to 5 of the 50 species of the older flora are present in the Upper Lykens, while 3 others occur in beds of the same period in the type section. If we next examine the distribution of the plants in the several fossiliferous beds of the type section at Pottsville, we find that of the plants in beds A–D, i. e., 700 feet or more below the Twin coal, all are common to the Lower Lykens coal group. In fact, all but 3 or 4 of the species represented in this division are included in and mostly confined to the Lower Lykens group in the mining region. We may therefore safely conclude that the highest bed, D, of this portion of the type section is not younger than the Lykens coal No. 4, with which its species are mostly in common. This portion of the type section appears to be clearly contemporaneous with the Lower Lykens group. The two corresponding sections will, therefore, be collectively included in what will be for the present designated the Lower Lykens division of the formation. Of the species in the Upper Lykens group, only 13 or 14, including 7 gymnosperms, occur in the lower group, either in the type section or in the mining region.

Passing again to that portion of the table relating to the type section, we find that the distribution of the plants occurring over Lykens coals Nos. 1–3 is confined almost exclusively to beds H–L of that section. The high degree of identity in the floras and the biologic evidence of the small balance of independent species unite in showing that each of the several beds in that portion of the type section is referable to, and probably lies within, the time interval marked by the Upper Lykens group of coals. We shall, accordingly, in further discussions, treat this group as belonging to an Upper Lykens division. Of the 125 species of plants found in this division, but 13 or 14, including the gymnosperms, are common to the Lower Lykens division, while 95 are, so far as observed, confined to the Upper Lykens division.

There remain two vertically restricted portions of the type section

for further consideration. The lower of these two, embracing beds E–G, from 570 to 640 feet below the Twin coal, has furnished a flora of from 17 to 19 species, 10 of which are common to the Lower Lykens division, and 6 or 8 to the Upper Lykens division. The lowest of these beds, 640 feet below the Twin coal, is bound to the Lower Lykens division by the presence of *Neuropteris Pocahontas* var. *inæqualis*, which is not, I believe, present at any point in the Upper Lykens division. *Eremopteris Cheathami* belongs in the upper portion of the formation, or in the Upper Lykens division, as, by its general distribution in other regions, does also *Alethopteris grandifolia*. *Trigonocarpum Helenæ* is, in general, rare in the Upper Pottsville of other regions, it being largely characteristic of beds of nearly the age of Lykens coal No. 4. Similarly bed F, 50 feet higher, is bound by *Alethopteris protaquilina* and *Neuropteris Pocahontas* to the Lower Lykens division, and perhaps more closely by *Eremopteris decipiens*, *Neuropteris tennesseana*, and *Callipteridium alleghaniense* to the Upper Lykens division. The Eremopterids and Mariopterids are largely characteristic of the upper Pottsville, while *Callipteridium alleghaniense* generally occupies a lower place in the sections in other regions. Considering the mixed composition of the floras of these two beds, it seems most expedient to regard them at present as belonging to the interval between the floras of Lykens coals No. 4 and No. 3. Bed G, which is but 20 feet higher than F, is temporarily placed in the same rubric—the Lower Intermediate division—between the Upper Lykens division and the Lower Lykens division, on account of ignorance of its flora. Should additional material come to light in this bed, which as yet has furnished but one fern species, *Neuropteris acutomontana*, it will probably be found referable to the Upper Lykens division.

The remaining uppermost plant beds, M and N, in the type section at 245 feet and 210 feet, respectively, below the Twin coal, have yielded as yet but 8 species, none of which occur in either the Lower Lykens division or the Lower Intermediate division. Four of the species are, however, common to the Upper Lykens division. Of the 8 species, viz, *Pseudopecopteris* cf. *squamosa*, *Pecopteris* sp., *Alethopteris Serlii*, *A. coxtoniana*, *Neuropteris ovata*, *N. Descrii?*, *Sphenophyllum cuneifolium* and *Sigillaria* cf. *lævigata*, the first named, *Pseudopecopteris* cf. *squamosa*, and *Alethopteris Serlii*, *Neuropteris ovata*, and *Sigillaria* cf. *lævigata*, are usually characteristic of the Coal Measures, while *A. coxtoniana* and the *Pecopteris* species appear to lie close below the base of the Lower Coal Measures at "Campbell Ledge" in the Northern Anthracite field. The phase of *Sphenophyllum cuneifolium* found in these beds is that common near the base of, but within, the Coal Measures. In brief, it is evident that, while several of the species from these beds are common to the Upper Lykens division,

the flora as a whole is perhaps more closely united with that of the Buck Mountain coal and the succeeding Lower Coal Measures. These two beds, which are obviously younger than the Upper Lykens division, yet are not less than 200 feet below the Twin coal, will, therefore, be treated as representative of an Upper Intermediate division, which, as will appear later, in the discussion of the floras, seems to be transitional to the Lower Coal Measures as that formation was defined by Rogers and has since been commonly recognized.

The combined distribution of the species between the four divisions of the Pottsville formation somewhat temporarily proposed above is condensed in the four columns at the right-hand border of the table. It may be summarized as follows (p. 790):

Table showing the observed geographic and stratigraphic

NOTE—The hyphens between the numbers of the coals indicate that the fossils were collected the species associated on a slab or rock fragment to identify the horizon

Names of species, stratigraphically arranged in two groups.	Lincoln-Lykens mining developments.																	
	Lower Lykens Coal group.												Upper Lykens Coal group.					
	Miller drifts, Coal 5.	Big Run mine, Coals 3-6.	Williamstown, Coals 3-6.	Brookside, Coal 6.	Kulpmin, Coals 5-6.	Lincoln, Coal 5.	East Brookside, Coals 4-6.	Brookside, Coals 1-5.	Brookside, Coal 4.	East Brookside, Coal 4.	Lincoln, Coal 4.	Lincoln, Coals 1-5.	Lincoln, Coals 2-3.	North Brookside, Coal 2.	Eureka drift (Lower), Coal 2.	New Lincoln, Coals 1-3.	Lincoln, Coal 1.	
GROUP No. 1—*From Lower Lykens section.*																		
Aneimites pottsvillensis D. W.												4						
Aneimites sp.																		
Eremopteris sp. No. 1								×?										
Mariopteris eremopteroides D. W.	×						5	5			?	5						
Mariopteris pottsvillea D. W.	?										✓	4				?		
Mariopteris sp.				✓								5 or 6						
Sphenopteris umbratilis D. W.																		
Sphenopteris asplenioides Stb.							4-5											
Sphenopteris Monahani D.W.				1 or 5								1 or 5						
Sphenopteris patentissima (Ett.) Schimp.							6?					1 or 5						
Sphenopteris novalincolniana D. W. var. antecedens												4 or 5						
Sphenopteris Lutheriana D.W.												4 or 5						
Sphenopteris dadeana D. W.																		
Alojopteris georgiana (Lx.)												4?						
Pecopteris serrulata Hartt (non Heer)								4?										
Alethopteris protaquilina D.W.								4?										
Alethopteris composita D.W.																		
Alethopteris sp.																		
Megalopteris sp.																		
Neuropteris Pocahontas D. W.					5?		5?											
Neuropteris Pocahontas var. pentias			?	5 or 6		5						5						
Neuropteris Pocahontas var. inaequalis					5							1 or 5						
Neuropteris Smithsii Lx.								4	4	4	4	4						
Asterocalamites scrobiculatus (Schloth.) Zeill												4						
Calamites Roemeri Goepp.	✓		×									+						
Asterophyllites parvulus Dn.							5?					1 or 5						
Calamostachys cf. lanceolata Lx.?																		

range of plants within the Pottsville formation in the type region.

from rock dumps of mingled material from those coals. Whenever it is practicable, by means of or coal, the number of the latter is placed opposite the species in question.]

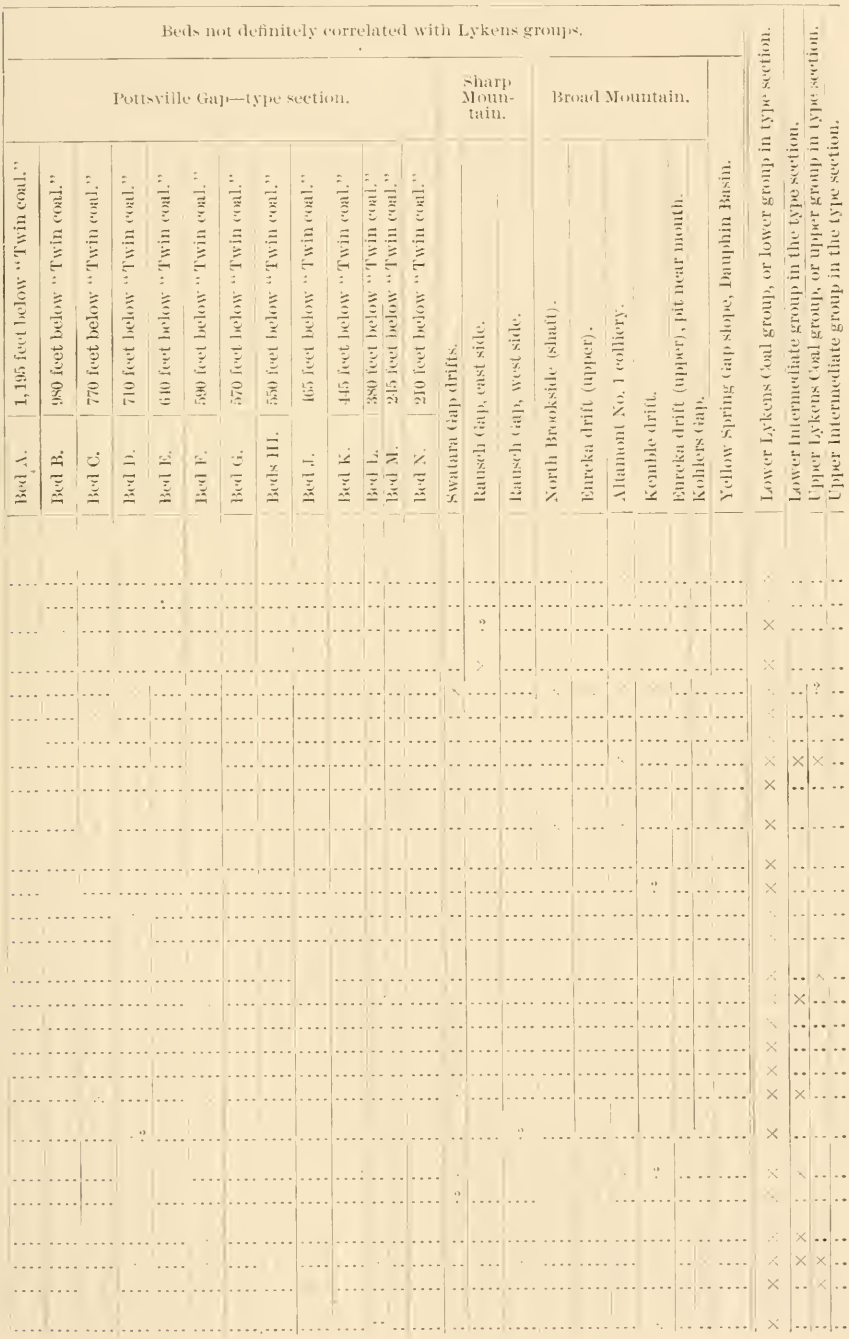

Table showing the observed geographic and stratigraphic range of

Names of species, stratigraphically arranged in two groups.	Lincoln-Lykens mining developments.																	
	Lower Lykens Coal group.												Upper Lykens Coal group.					
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GROUP No. 1—*From Lower Lykens section*—Cont'd.																		
Volkmannia crassa Lx									×			4?						
Sphenophyllum tenue D. W.									×	×		4		?		?		
Lepidodendron alabamense D. W.		?			5?		×					4 or 5						
Lepidodendron Veltheimii Stb																		
Lepidodendron clypeatum Lx.							4?		×			4 or 5						
Lepidophloios sp					5?				×									
Lepidostrobus pennsylvanicus D. W					×				4			2 or 3				2 or 3		
Lepidostrobus cf. ornatus L. & H						×	×											
Lepidophyllum quinnimontanum D. W		×				×						4 or 5						
Lepidophyllum lanceolatum L. & H. var. virginianum		×			5?			×										
Sigillaria ichtyolepis (Presl) Corda					×			×										
Sigillaria kalmiana D. W					5 or 6													
Sigillariostrobus ? incertus D. W												×						
Cordaites Robbii Dn								×	×		×					×	×	
Cardiocarpon elongatum Newb											var					×		
Trigonocarpum ampullaeforme Lx		×			var.	var	var	var	var	var		1 or 2	var		var	var	×	
Trigonocarpum Helenæ D. W					5?	×	5?	×	×			4 or 5	×			×		
Trigonocarpum Dawsonianum D. W							×				×					×		
Rhabdocarpos speciosus D. W.									×									
Whittleseya Campbelli D. W.					×	×	×	×	×	×		×			×	×	×	
Carpolithes orizæformis Lx. MSS							×				×				×	×	×	
Carpolithes sp											×							
Sporangites sp									×									
GROUP No. 2—*From Upper Lykens section.*																		
Eremopteris subelegans D. W.																		
Eremopteris sp. No. 2																		

plants within the Pottsville formation in the type region—Continued.

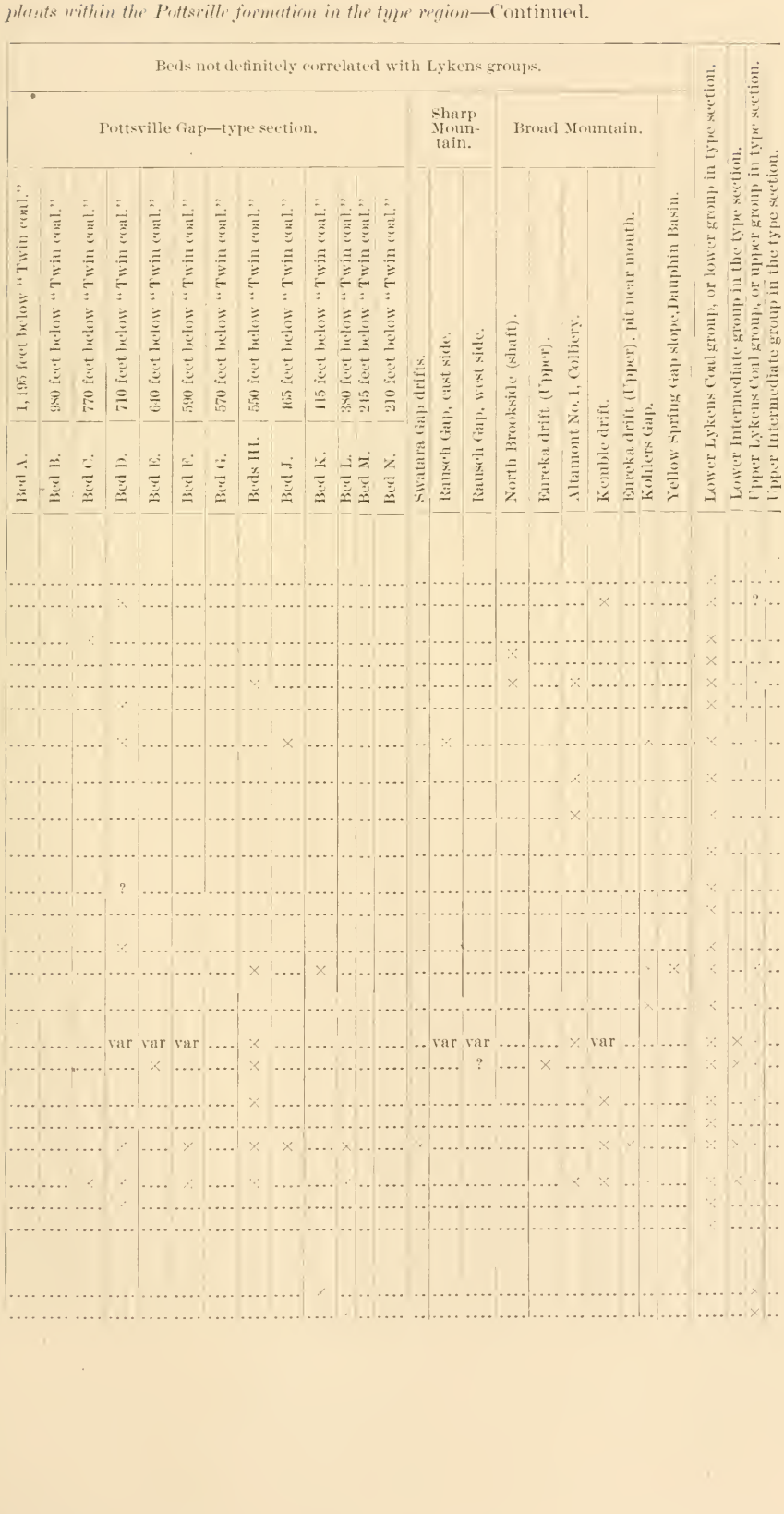

Table showing the observed geographic and stratigraphic range of

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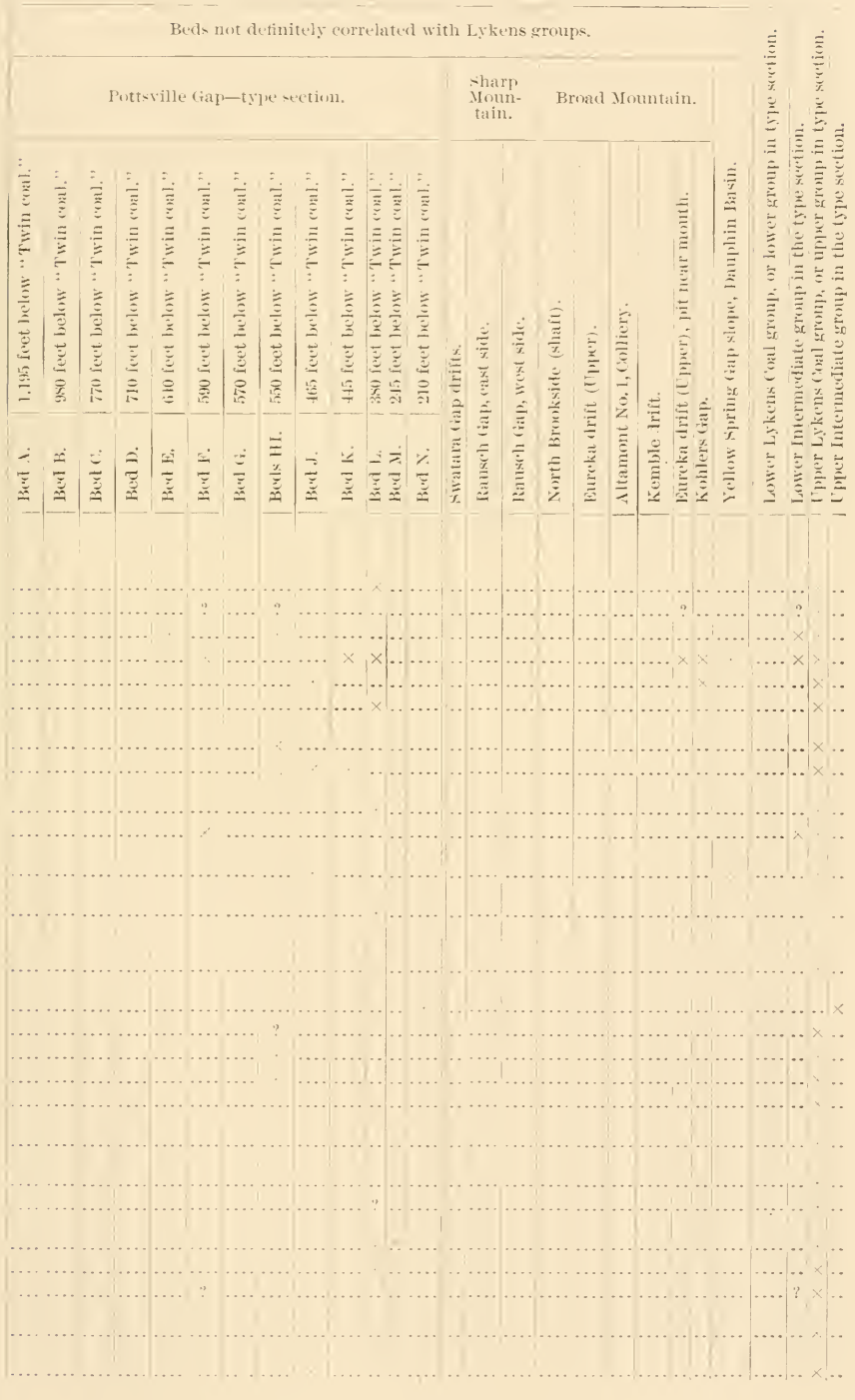
GROUP No. 2.—*From Upper Lykens section*—Cont'd.																	
Eremopteris dissecta D. W																	
Eremopteris lincolniana D. W.												2				2	
Eremopteris Cheathami Lx												2 or 3					
Eremopteris decipiens (Lx)												2 or 3				2 or 3	?
Eremopteris Aldrichi D. W												?					
Mariopteris Phillipsi D. W												2 or 3					
Mariopteris Phillipsi var. intermedia																	
Mariopteris pygmæa D. W												2	2		×	2 or 3	
Mariopteris nervosa (Brongn.) Zeill. var. lincolniana												1?				>	
Mariopteris tennesseeana D. W.												2 or 3	×				
Mariopteris tennesseeana var. hirsuta												2 or 3?					
Mariopteris cf. acuta (Brongn.) Zeill																	
Pseudopecopteris obtusiloba (Stb.) Lx. var. mariopteroides																	
Pseudopecopteris cf. squamosa (Lx.) D. W																	
Sphenopteris Lehmanni D. W.																	
Sphenopteris Kaercheri D. W.																2	
Sphenopteris simulans D. W.																	
Sphenopteris sp																	
Sphenopteris divaricata (Goepp.) Gein. & Gutb																2?	
Sphenopteris microcarpa Lx. var. dissecta																2 or 3	
Sphenopteris Harttii Dn.																2?	
Sphenopteris subpinnatifida D. W																	
Sphenopteris furcata Brongn.																>	
Sphenopteris Royi Lx																2 or 3	
Sphenopteris novalincolniana D. W.																>	
Sphenopteris palmatiloba D. W.																	

plants within the Pottsville formation in the type region—Continued.



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GROUP No. 2.—*From Upper Lykens section*—Cont'd.																	
Sphenopteris palmatiloba var. squarrosa																1?	+
Sphenopteris mixtilis D. W.												2 or 3				×	..
Sphenopteris pilosa Dn.																	..
Zeilleria cf. avoldensis Stur												1 or 2					..
Oligocarpia crenulata D. W.																	..
Oligocarpia alabamensis Lx.												×					..
Pecopteris sp.																	..
Alethopteris Lacoei D. W.															×	2	..
Alethopteris lonchitica (Schloth.) Stb.												1–3?					..
Alethopteris lonchitica var. multinervis												2 or 3				×	..
Alethopteris alata D. W.												2 or 3?					..
Alethopteris lincolniana D. W.												2 or 3	×				..
Alethopteris magnifolia D. W.												×				2	..
Alethopteris grandifolia Newb.																	..
Alethopteris discrepans Dn.																×	..
Alethopteris Serlii (Brongn.) Goepp.																	..
Alethopteris coxtoniana D. W.																×	..
Alethopteris Evansii Lx.												2 or 3					×
Alethopteris Evansii var. grandis												2 or 3?				×	..
Callipteridium alleghaniense D. W.												2 or 3			×	2 or 3?	..
Callipteridium suspectum D. W.																	..
Callipteridium pottsvillense D. W.																	..
Megalopteris plumosa D. W.																	..
Neriopteris lanceolata Newb.																	..
Neuropteris Elrodi Lx.												2 or 3	×			2	..
Neuropteris Aldrichi (Lx.)																	..
Neuropteris acutominana D. W.												2 or 3			?		..

plants within the Pottsville formation in the type region—Continued.

Beds not definitely correlated with Lykens groups.																										
Pottsville Gap—type section.														Sharp Mountain.		Broad Mountain.										
Bed A. 1,195 feet below "Twin coal."	Bed B. 980 feet below "Twin coal."	Bed C. 770 feet below "Twin coal."	Bed D. 710 feet below "Twin coal."	Bed E. 610 feet below "Twin coal."	Bed F. 590 feet below "Twin coal."	Bed G. 570 feet below "Twin coal."	Beds H I. 530 feet below "Twin coal."	Bed J. 465 feet below "Twin coal."	Bed K. 415 feet below "Twin coal."	Bed L. 380 feet below "Twin coal."	Bed M. 245 feet below "Twin coal."	Bed N. 210 feet below "Twin coal."	Swatara Gap drifts.	Rausch Gap, east side.	Rausch Gap, west side.	North Brookside (shaft).	Eureka drift (Upper).	Altamont No. 1, Colliery.	Kemble drift.	Eureka drift (Upper), pit near mouth.	Kohlers Gap.	Yellow Spring Gap slope, Dauphin Basin.	Lower Lykens Coal group, or lower group in type section.	Lower Intermediate group in the type section.	Upper Lykens Coal group, or upper group in type section.	Upper Intermediate group in the type section.
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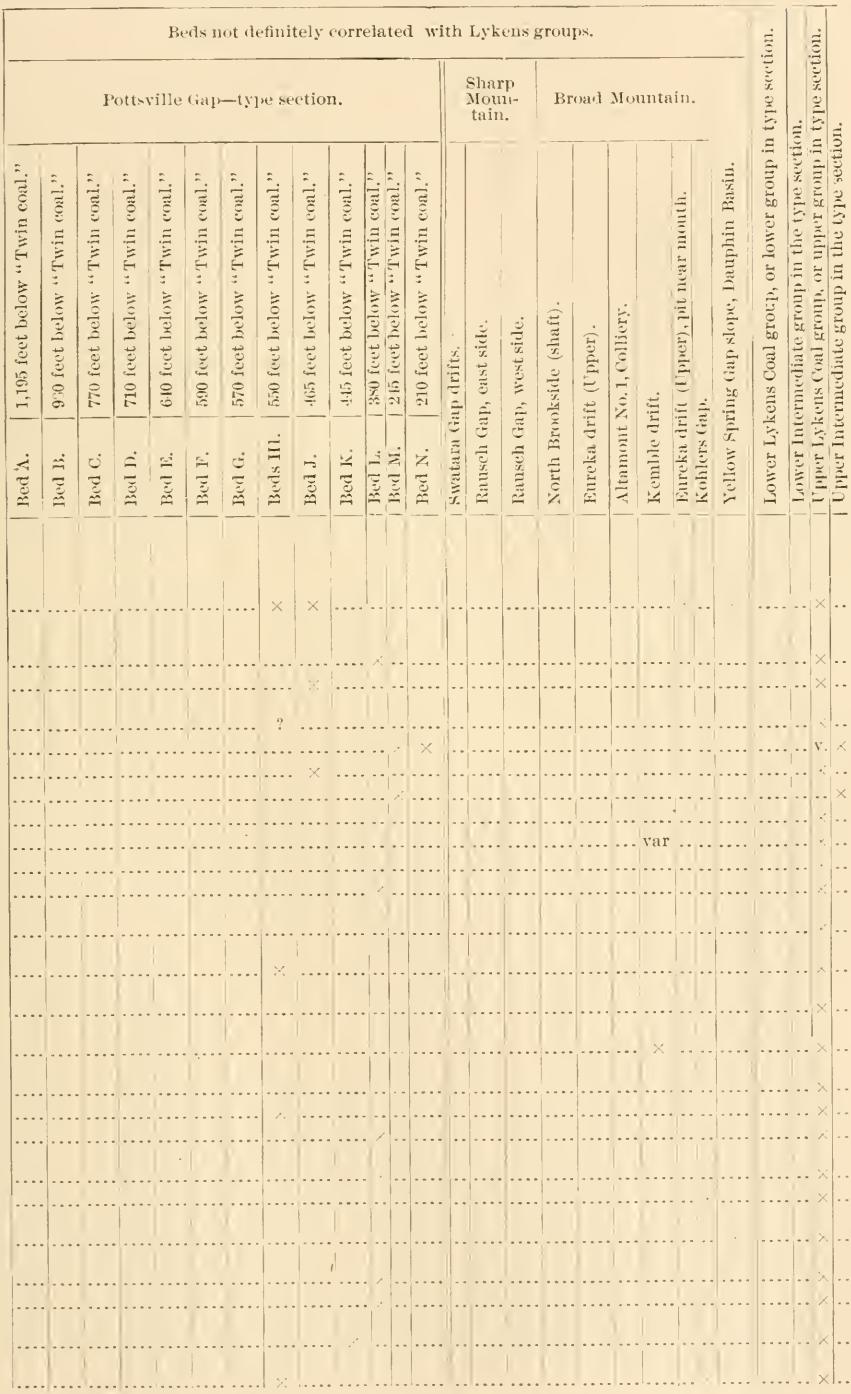
GROUP No. 2—*From Upper Lykens section*—Cont'd.																		
Neuropteris tennesseeana Lx. Mss																2 or 3		
Neuropteris tenuifolia (schloth.) Brongn. var. humilis																1		
Neuropteris sp																		
Neuropteris aff. heterophylla Brongn												2?						
Neuropteris ovata Hoffm												var.				var.		
Neuropteris hirsutina D. W																		
Neuropteris Desorii Lx.?																		
Neuropteris fimbriata Lx																		
Neuropteris gigantea stb														2		2		
Neuropteris lunata D. W												1				1		
Calamites Hauerj stur																		
Calamites approximatus schloth																		
Asterophyllites arkansanus D. W												1,2or3						
Asterophyllites pennsylvanicus D. W												2 or 3						
Asterophyllites cf. rigidus stb. Brongn																		
Annularia platiradiata Lx. Mss																		
Annularia acicularis Dn																2 or 3		
Annularia cuspidata Lx																		
Annularia latifolia Dn. Kidst																		
Annularia laxa Dn																		
Calamostachys Knowltoniana D. W																		
Palaeostachya alabamensis D W																		
Macrostachya sp																		
Sphenophyllum tenerrimum Ett. var elongatum												2				2		
Sphenophyllum bifurcatum Lx																	3	

plants within the Pottsville formation in the type region—Continued.



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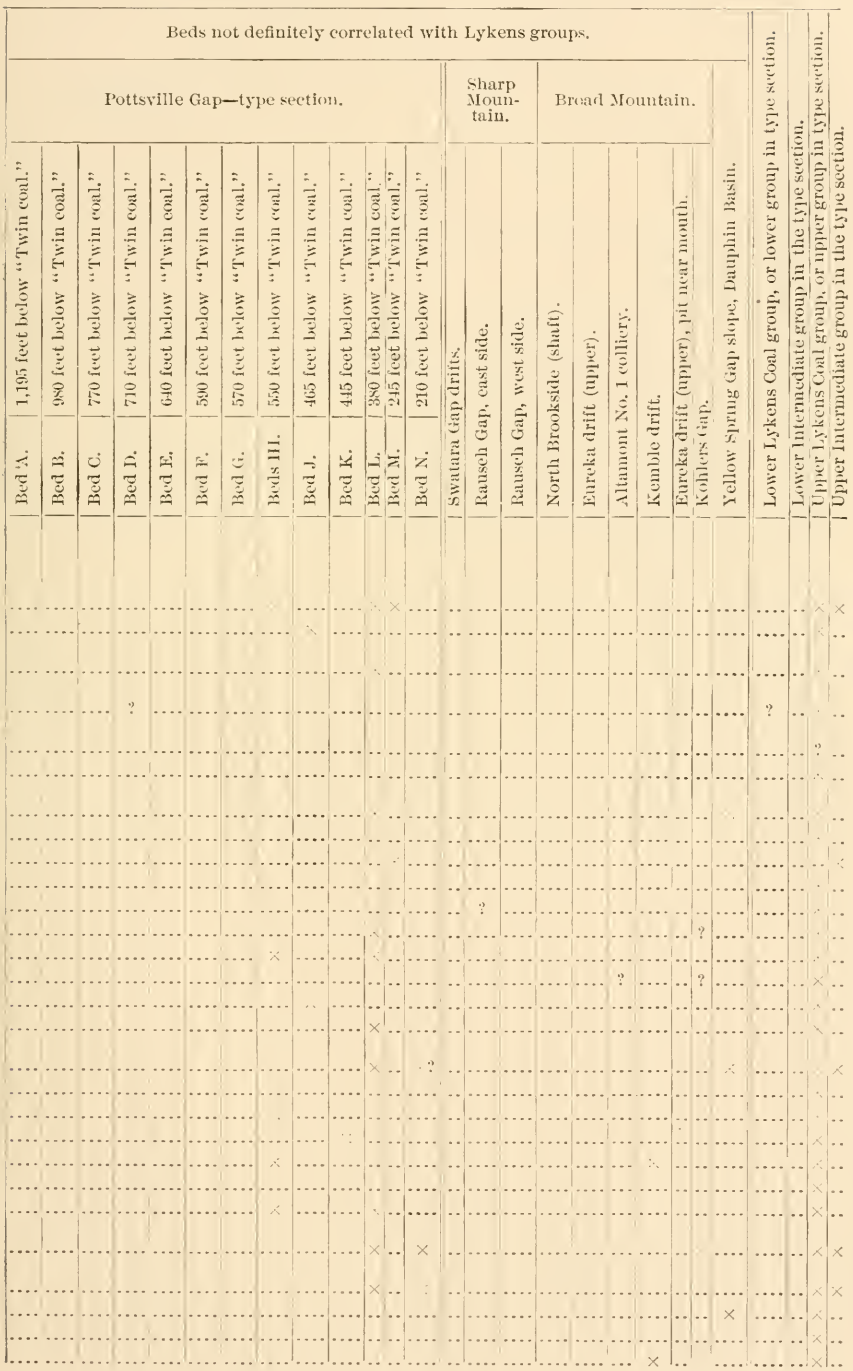
GROUP No. 2—*From Upper Lykens section*—Cont'd.																		
Sphenophyllum cuneifolium (Stb.) Zeill												1,2 or 3				×	
Bowmannites? sp.																		
Lepidophloios acutimontanus D. W.																		
Lepidophyllum campbellianum Lx.												2 or 3				×	
Lepidophyllum linearifolium Lx.?																?	
Lepidocystis fraxiniformis Lx.												1					
Bothrodendron arborescens (Lx.)																		
Sigillaria lincolniana D. W.												2 or 3				×	
Sigillaria cf. levigata Brongn.																		
Sigillaria sp.												2						
Stigmariopsis Harveyi Lx. MSS																		
Cordaites Phillipsi D. W.																×		
Cordaites angustifolius Dn.																		
Cordaites grandifolius Lx.																×		
Artisia irregularis D. W.																		
Cordaianthus spicatus Lx.																		
Cardiocarpon bicuspidatum (Stb.) Newb. var. ohioense																		
Cardiocarpon cuyahogae D. W.												2				×		
Cardiocarpon minus Newb.																		
Cardiocarpon late-alatum Lx.																		
Cardiocarpon disculum D. W.																×		
Cardiocarpon orbiculare Ett.												1,2 or 3						
Cardiocarpon cornutum Dn.																×		
Cardiocarpon elongatum Newb. var. intermedium																		
Cardiocarpon annulatum Newb.																		
Cardiocarpon Wilcoxi D. W.																		
Cardiocarpon Girtyi D. W.												1 or 2						
Cardiocarpon obliquum Dn.																×		

plants within the Pottsville formation in the type region—Continued.



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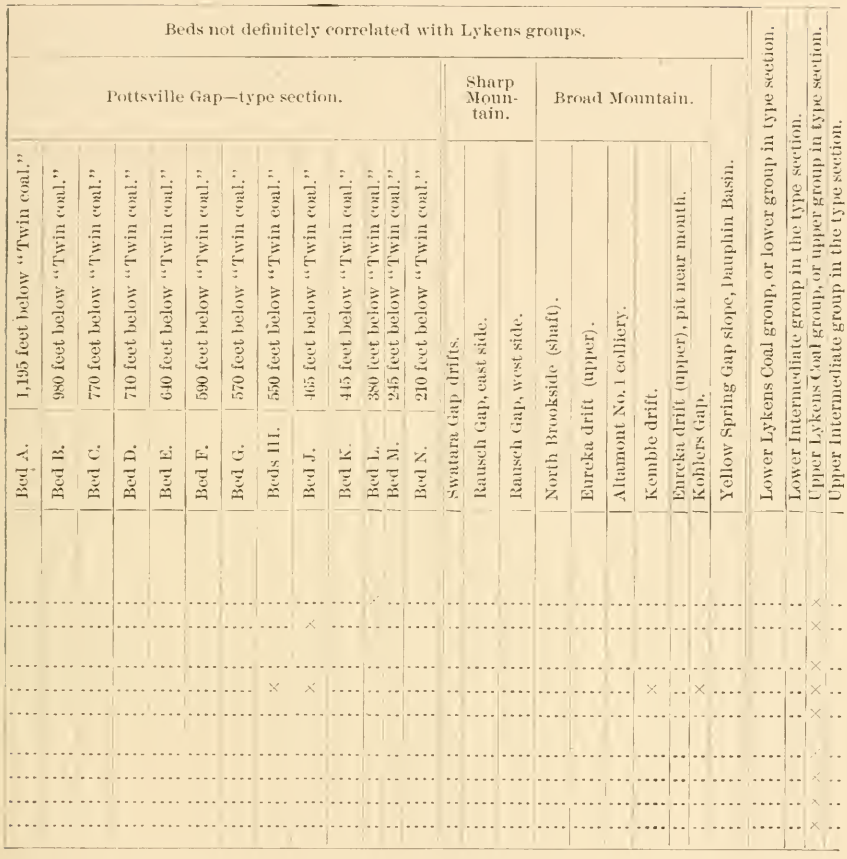
GROUP No. 2.—*From Upper Lykens section*—Cont'd.																		
Trigonocarpum Noeggerathi (Stb.) Brongn												1 or 2					
Trigonocarpum ornatum Newb																	
Rhabdocarpos Walcottianus D. W																1 or 2	
Whittleseya Lescuriana D. W																	
Whittleseya microphylla Lx																2 or 3	
Whittleseya elegans Newb. var. minor												1,2 or 3	×				
Carpolithes fragarioides Newb.																×	
Carpolithes transsectus Lx																×	
Fayolia sp														×			

plants within the Pottsville formation in the type region—Continued.



Analysis of the distribution of the species by divisions in the formation.

Division.	Total number of species therein.	Common to Lower Lykens division.	Common to Lower Intermediate division.	Common to Upper Lykens division.	Common to Upper Intermediate division.	Exclusively confined to the division.
Lower Lykens	50	----------	10	14–15	0	33
Lower Intermediate	17–19	10	--------	13	0	2
Upper Lykens	125	14–15	11–13	----------	7	95
Upper Intermediate	11	0	0	7	--------	4

FLORAS OF THE LOWER LYKENS DIVISION.

Before discussing the probable equivalents or approximate horizons, with reference to either the Lykens coals or the type section of the formation, of the more or less isolated beds or developments in the southern portions of the anthracite field, including those enumerated in the section of the table to the right of the Pottsville Gap beds, it is desirable to indicate as clearly as is practicable, without recourse to paleontologic descriptions, those species which, so far as has been observed, are apparently largely characteristic of the principal levels. It is also advisable to enumerate those which appear to especially attend and mark the vicinity of the economically important and therefore more interesting horizons of the several Lykens coals. The latter may be reviewed in ascending order.

FLORA OF THE "ZERO" AND NO. 6 COALS.

Of the characters of the plants over the "zero" bed, the lowest of the Lykens coals, no precise information is at hand. At Williamstown,[1] the only point at which the bed has been exploited, but little mining was ever done in the coal, and the bed was so long ago abandoned that it has not been practicable to obtain any fossils therefrom. It appears probable, however, on account of its proximity to the succeeding coals (38 feet below No. 6), that little difference will be observed in its flora, fragments of which may possibly have been gathered from the rock dump at the Williamstown mine. Likewise the mingling of the roof shales from the Lykens coals No. 6, or the "Little bed," and coal No. 5, in the rock dumps, as at Big Lick, Williamstown, and the Brookside mines, renders it, for the most part, impossible to discriminate between the fossils from these coals at this point, although it has fortunately been possible to procure distinct collections from the higher coal. A small collection from the roof of Lykens coal No. 6, within the mine

[1]Atlas Southern Anthracite Field, Pt. III, mine sheet xix; Pt. VI, cross-section sheet xx; Pt. IV, columnar-section sheet vii, section 8.

at Brookside, was, however, obtained through the cooperation of the Philadelphia and Reading Coal and Iron Company.

Excluding *Whittleseya Campbelli*, which in some form is nearly everywhere present in the Pottsville formation, and *Sphenopteris patentissima*, which is more abundant in the neighborhood of coals No. 5 and 4, there remain *Neuropteris Pocahontas* var. *pentias* and *Alethopteris composita*, the latter of which has not been found in any other bed. The variety of *Neuropteris Pocahontas* has, perhaps, not been seen from a higher level than the roof of No. 5. Its presence, accordingly, in a coal but 50 feet lower is quite natural. It must therefore be understood that the shales attending coal No. 6 have not yet revealed any floral characters of value, though the default may be due to lack of specimens known to have come from this level, rather than entirely to its propinquity to coal No. 5.

FLORA OF LYKENS COAL NO. 5.

The collective flora from the roof of Lykens coal No. 5, also known as the "Big bed," or the "Lykens Valley bed,"[1] may readily be compiled from the first section in the table of distribution. As will be noted in glancing at the vertical range of the species in the latter, a large portion of the plants are common to the flora of coal No. 4, while others, perhaps exclusively from this bed, are represented by specimens whose mingling in the rock dump with material from No. 6 deprives them of any present stratigraphic trustworthiness. Among the specimens definitely known to come from the roof of this coal the most important species are: *Mariopteris eremopteroides*, *Sphenopteris asplenioides*, *S. patentissima*, *Neuropteris Pocahontas* and its two varieties, *Calamites Roemeri*, *Asterophyllites parvulus*, *Lepidophyllum quinnimontanum*, *Lepidophyllum lanceolatum* var. *virginianum*, and *Sigillaria kalmiana*. *Eremopteris* sp. No. 1, *Calamostachys* cf. *lanceolata*, *Lepidodendron alabamense*, and a *Sigillaria* which I refer, with a little doubt, to *S. ichtyolepis*, are species of restricted range, but the circumstances attending the collection of some of the fossils make it uncertain whether their source is exclusively in the region of coal No. 5. The most abundant and characteristic species is *Neuropteris Pocahontas* var. *pentias*, which rarely fails to be present in large numbers, even in a small collection. The variety *inaequalis*, which is more common in the roof of Lykens coal No. 4, is also present. Another form, which throughout the Wiconisco Basin seems to be confined to the same stage, is the beautiful *Mariopteris eremopteroides* illustrated in Pl. CLXXXIX. *Sphenopteris asplenioides* here, as in other regions, exhibits the diminutive round-lobed or *Dicksonioides* type common in the

[1] "No. 2" in the nomenclature employed for this vicinity in Rogers, Geology of Pennsylvania, Vol. II, Pt. II, 1858, p. 192.

lower portion of the Pottsville formation. *Sphenopteris patentissima* appears to be present at this level, though more common in and characteristic of the roof of coal No. 4. *Calamostachys* cf. *lanceolata*, collected from the East Brookside rock dump, may be assumed to have come from No. 4, its occurrence in other regions being as high as the flora of No. 4, or even higher. The same is true of *Lepidodendron alabamense*. *Lepidophyllum lanceolatum* var. *virginianum* and *Lepidophyllum quinnimontanum* are essentially characteristic of the lower Pottsville in all regions, but the former is usually predominant in beds lower than those in which the latter is common.

From an examination of the table, as well as from the inspection of the collections, we may conclude that the almost invariable appearance of *Mariopteris eremopteroides* or the lax form, var. *inaequalis*, of *Neuropteris Pocahontas*, as well as the occasional presence of a number of the ferns slightly more characteristic of No. 4, serves to distinguish the stage of coal No. 5 from the basal portion of the Pottsville formation, while the species first mentioned, together with the always abundant *Neuropteris Pocahontas* var. *pentias*, *Neuropteris Pocahontas*, and *Lepidophyllum lanceolatum* var. *virginianum*, likewise assist in discriminating between the floras of coals No. 5 and No. 4. In the latter differentiation the absence of those plants which are characteristic of the roof shales of No. 4 is perhaps an equally valuable criterion, though negative in its nature.

PALEONTOLOGIC FEATURES OF THE ROOF SHALES OF COAL NO. 4.

The flora of the roof shales of Lykens coal No. 4 is perhaps the most readily recognizable among those attending the series of the Lykens coals. While it contains a large percentage of species that are also found in the roof of No. 5, as may be noted by reference to the table, and while its facies is distinctly *lower* Pottsville as compared with floras of coals 2 or 3, it almost invariably contains several species which are not only restricted to nearly this level in the Southern Anthracite field, but which are also observed, similarly associated, and restricted as to vertical range, in other regions. These are *Ancimites pottsvillensis*, *Mariopteris pottsvillea*, *Alethopteris protaquilina*, *Neuropteris Smithsii*, *Volkmannia crassa*, and *Sphenophyllum tenue*. Additional species, hitherto found only at this level in the Southern Anthracite field, are *Sphenopteris novalincolniana*, *S. Lutheriana*, *Rhaplocarpos speciosus*, and a form of *Sporangites*. Of the species which are found at other horizons, *Sphenopteris patentissima*, the small form of *S. asplenioides*, *Aloiopteris georgiana*, *Lepidodendron alabamense*, and *Trigonocarpum Helenæ* are more especially common in this stage, where they are generally associated with the species first enumerated. In fact, *Ancimites pottsvillensis*, *Mariopteris pottsvillea*,

Neuropteris Smithsii, *Sphenophyllum tenue*, *Lepidodendron alabamense*, and *Trigonocarpum Helenæ* are among the characteristic species of this stage of the Pottsville formation throughout the Appalachian region. The most common, and therefore the most useful of these in the Southern Anthracite field are *Mariopteris*, *Neuropteris*, and *Sphenophyllum*. In fact, if we were to employ a paleontologic term for this portion of the section, the latter might appropriately be designated the *Mariopteris pottsvillea* zone.

COMPARISON OF THE LOWER PORTION OF THE TYPE SECTION WITH REFERENCE TO THE LYKENS COAL HORIZONS.

Owing to the densely conglomeratic constitution of the basal portion of the formation at the type locality, comparatively few fossils have been obtained from beds A and B, which clearly belong to the Lower Lykens division: but while the materials from bed B of the section are quite insufficient to form a basis for horizontal comparisons, we find that the presence of *Mariopteris* sp. No. 1, which is perhaps inseparable from *Mariopteris eremopteroides*, *Neuropteris Pocahontas*, and *Sphenopteris patentissima* in bed C, 770 feet below the Twin coal, is entirely compatible with a stratigraphic position not far from Lykens coal No. 5. At the same time, the presence in bed D, 710 feet below the Twin coal, of *Mariopteris pottsvillea*, *Sphenopteris dadeana*, *Aloiopteris georgiana*, *Neuropteris Pocahontas* var. *inæqualis*, *Neuropteris Smithsii*, and *Sphenophyllum tenue* strongly points to a place near the level of Lykens coal No. 4. Although several species are known to occur in beds above No. 4, they are rare in higher horizons, while the more important percentage of species which appear to be largely characteristic of the Lower Lykens division more than counterbalances them. Of greater correlative value, however, are such species as *Mariopteris pottsvillea*, *Neuropteris Smithsii*, and *Sphenophyllum tenue*, which are in general characteristic of the horizon of No. 4 coal, and whose evidence is strengthened by the accompanying species enumerated above. In short, the plants of bed D indicate a horizon approximate to that of the Lykens coal No. 4 (White's bed), about 710 feet below the Twin coal in the type section. It is probably not higher; it may be slightly lower. Bed C, on the other hand, 770 feet below the Twin coal, is probably lower than the No. 4 coal, and may have been deposited at the same time as the Lykens coal No. 5.

I do not wish to be understood as regarding the coals adjacent to beds C and D in the type section as unquestionably identical with Lykens coals 5 and 4, respectively. The obvious variation in the beds of the Pottsville formation, especially as regards the number of the coals, as shown in sections located but a few miles distant, and the frequently observed entire disappearance of the principal coals of

the field, as revealed by borings not far from the Lincoln region,[1] can not fail as convincing arguments against the free application, in the Pottsville formation of the Southern Anthracite field, of the correlative methods employed by geologists working in the interior of the Appalachian trough, where, in the several bituminous basins, the beds are relatively uniform and clearly persistent over great areas. That one of the thin coals occurring in the Pottsville Gap section nearly 700 feet below the Twin coal is contemporaneous with and equivalent in point of time to a portion of the No. 4 coal at Lincoln or Williamstown is perhaps not improbable, since the favorable conditions for exclusively carbonaceous deposition may have been synchronous at both points, and the testimony of the fossils points toward the latter. It is likewise possible that the 1-foot coal accompanying the 2 feet of dark shales at bed C may represent Lykens coal No. 5. It is, however, extremely improbable that either of these coals extends in a continuous carbonaceous terrane from the type section at Pottsville to the very valuable deposit in the Lincoln district.

The stratigraphic position of bed A in the topmost stratum of red shale at the base of the section probably justifies the assumption that it is older than any of the Lykens coals. Its very small flora, of Lower Carboniferous facies, appears to warrant this assumption, although it is too meager to serve as a foundation for satisfactory comparison.

FLORA OF THE LOWER INTERMEDIATE DIVISION.

BRIEF EXISTENCE OF A TRANSITION FLORA.

The relative distinctness, from a stratigraphic standpoint, of the floras of the Upper Lykens division, as compared with those of the Lower Lykens division, has already been remarked in connection with the proposed subdivision of the Pottsville formation according to the concomitant grouping of the economic coals and the fossils. It may be noted at this point that the paleontologic difference between the lower and the upper groups, which, excluding the gymnosperms and certain vertically widely distributed Lycopodiales, have comparatively few species in common, is probably due in part at least to the interval between Lykens coals Nos. 4 and 3, which is about 250 feet in the Lincoln region. This interval, of which we have from the Lincoln region no paleontologic representation in the collections, and which is therefore not assigned to either the upper or the lower division, still remains accordingly a paleontologically unknown quantity. Yet, notwithstanding the inferential conclusion that it contains a transitional mingling of Upper and Lower Lykens floral characters, such as occurs in the interval (Lower Intermediate division) between 570 and 700 feet below the Twin coal in the type section, the vertical distance involved is

[1] See the records of diamond-drill bore holes on Broad Mountain, platted in great detail on columnar-section sheet ix, Atlas Southern Anthracite Field, Pt. IV.

comparatively so little, when we at once take into view the entire section and the notable differences between the flora above and that below, as to strongly emphasize the rapidity of the specific floral changes which it masks. As has previously been mentioned, the plants of bed G of the Pottsville Gap section are probably referable to the Upper Lykens division. Should plants be collected from several beds between coals No. 3 and No. 4 in the Lincoln-Lykens mining districts, it is not improbable that some of the terranes will show closer paleontologic connections with one division or the other; but the plants in the interval in the type section, though few in number, indicate that within certain limits of a relatively thin zone of the sections the boundary, if drawn as between the Lower Lykens division and the Upper Lykens division, will be largely arbitrary through beds with a mixed flora. The case in hand well illustrates the rapidly changing facies of the floras of the Appalachian region during Pottsville time.

FLORAS OF THE UPPER LYKENS DIVISION.

FLORA OF LYKENS COALS NOS. 3 AND 2.

Fossil plants have been collected from the roof shales of Nos. 1, 2, and 3 of the upper Lykens coals in the vicinity of Lincoln. It has been impossible to make a collection from coal No. 1½, since the New Lincoln colliery, where it was formerly slightly worked, has for a number of years been abandoned, the mineral from the other beds on the property being brought to light at the Lincoln mine. Accordingly, while it is not impossible that stray specimens from this bed may still have been accessible in the rock dump, it is probable from the very small extent of the workings that few, if any, were collected. At least it has not been possible to recognize such, and the specimens, if present, are presumably included in the column of the table devoted to the stratigraphically undifferentiated material from coals 1 to 3, inclusive, at the New Lincoln mine.

Of the floras derived from the upper Lykens coals, by far the most interesting are those associated with the neighboring coals, Nos. 2 and 3. The proximity of these beds, which are separated by but 3 inches of dirt at the New Lincoln mine and by strata probably nowhere far exceeding 30 feet in the Lincoln workings, results generally in the removal of both coals at once and the mingling of the roof shales of No. 2 with the parting between Nos. 2 and 3. Separate collections were, however, obtained from both, that exclusively from the parting, which may be regarded as the roof of No. 3, being procured at the Lincoln mine, while specimens from the cover of coal No. 2 were gathered at the North Brookside slope[1] in that bed and from the lower

[1] Atlas Southern Anthracite Field, Pt. III, mine sheet xvii; Pt. IV B, columnar-section sheet x, section 8; Pt. VI, cross-section sheet xix, section 25.

Eureka drift.[1] Of the entire 125 species so far discovered in the shales over the coals of the Upper Lykens group, not more than 14 or 15, including the vertically widely distributed gymnosperms, are found in the Lower Lykens group. By reference to the preceding table of distribution, it will at once be seen that of the fern flora but 2 species, *Sphenopteris asplenioides* and *Pecopteris serrulata*, present in the Lower Lykens division, are also apparently present in the roof shales of the mined upper Lykens coals, or in the beds of the type section, which, on the paleontologic evidence, I refer to the same division as the upper Lykens coals. *Calamites Roemeri*, *Asterophyllites parvulus*, *Lepidodendron clypeatum*, *Lepidostrobus pennsylvanicus*, and the five gymnosperms, which occur in the Lower Lykens division, have a relatively wide distribution in the formation. *Sphenopteris asplenioides* appears to be extremely rare in this division of the Southern Anthracite field, though it occurs as a large form in beds of the same age in the southern Appalachian region. *Pecopteris serrulata* is usually common in beds of this age. *Sphenophyllum tenue* is, on the other hand, extremely rare at so high a level; it, like *Trigonocarpum Helenæ*, being usually characteristic of the zone of No. 4 coal, or lower.

The zone of coals Nos. 2 and 3 is, in general, especially characterized by the presence of broad- or round-pinnuled forms of *Eremopteris;* by forms of *Mariopteris* approaching the original *muricata* type; by the large number of Sphenopterids, especially of the Hymenophyllous group, as well as by a Pecopteroid form; by the presence of the large, lax, and distant-nerved Alethopterids of the types of *A. discrepans* and *A. grandifolia;* by the *Megalopteris* types; by the *Elrodi* and *gigantea* types of *Neuropteris;* by the delicate *Asterophyllites* forms; by the early *Annulariæ;* the dissected *Sphenophylla;* the numerous gymnosperms, including *Cordaites* and the broad-leafed *Whittleseyæ;* as well as by a great abundance and variety of fruits. As more peculiar to this zone, specific mention should be made of—

Eremopteris Cheathami.
Mariopteris pygmæa.
Mariopteris tennesseeana.
Sphenopteris Lehmanni.
Sphenopteris Kaercheri.
Sphenopteris divaricata.
Sphenopteris Harttii.
Sphenopteris Royi.
Sphenopteris palmatiloba.
Alethopteris Lacoei.
Alethopteris grandifolia.
Alethopteris Evansii.
Callipteridium alleghaniense.
Neuropteris Elrodi.
Neuropteris tennesseeana.
Asterophyllites arkansanus.
Sphenophyllum tenerrimum var. elongatum.
Sphenophyllum bifurcatum.
Stigmariopsis Harveyi.
Cardiocarpon Cuyahogæ.
Cardiocarpon minus.
Carpolithes transsectus.
Whittleseya microphylla.
Whittleseya elegans var. minor.

[1] Station 33, Pl. CLXXX. Atlas Southern Anthracite Field, Pt. III, mine sheet xvi; Pt. IV B, columnar-section sheet x, section 6; Pt. VI, cross-section sheet xvii, section 23.

In addition to the plants specially mentioned above, there remain a number of new species which are as yet unknown outside of the field, and which, as may be observed in the table, occur only in this zone.

The species enumerated above, which paleobotanists will at once recognize as preponderantly common to the flora accompanying the Sewanee coal in Tennessee,[1] are essentially characteristic of this zone of the Upper Lykens division. Many of them, such as *Eremopteris Cheathami*, *Mariopteris tennesseeana*, *Sphenopteris Royi*, *Sphenopteris pilosa*, *Alethopteris Evansii*, *Neuropteris tennesseeana*, *Carpolithes transsectus*, *and Whittleseya microphylla*, have, so far as I know, never yet been found at any considerable distance from this zone in the Appalachian trough.

The flora in the roof of Lykens coal No. 2 reveals, as compared with that in the roof of No. 3, a slight difference, consisting of the presence of a few species of usually slightly higher occurrence and several forms which, in the Southern Anthracite field, I have found at no other horizon. As referable to the former category the following may be mentioned:

Eremopteris decipiens.
Eremopteris dissecta.
Mariopteris pygmæa.
Alethopteris Lacoei.
Alethopteris magnifolia.
Neuropteris Elrodi.
Neuropteris gigantea var.
Asterophyllites arkansanus.
Sphenophyllum bifurcatum.
Sphenophyllum tenerrimum var. elongatum.
Cardiocarpon Cuyahogæ.
Whittleseya elegans.

The peculiar elements which characterize the flora of Lykens coal No. 2 at every locality from which a considerable collection of specimens has been obtained, and by which it would seem that, in the western portion of the Southern Anthracite field, the horizon may almost invariably be recognized, include *Mariopteris pygmæa*, *Sphenopteris Lehmanni Alethopteris Lacoei*, and *Neuropteris Elrodi*. To this group of species may also be added *Sphenophyllum tenerrimum* var. *elongatum*, although in other fields this species has a somewhat higher distribution, and such, we may anticipate, will be the case outside of a restricted area in the western portion of the Southern Anthracite field. It may be noted that even where drifted, at a point about 550 feet below the Twin coal, above the wagon road on the east side of the gap below Pottsville, and at a point along an abandoned tramway near the apex of the mountain on the west side of Westwood Gap, this horizon reveals the same association of species in their identical forms. These species appear to attend Lykens coal No. 2 in the Southern Anthracite field, just as *Eremopteris Cheathami*, *Sphenopteris Royi*, *S. palmatiloba*, *S. pilosa*, *Mariopteris tennesseeana*, *Alethopteris Evansii* and *Neuropteris tennesseeana* usually occur in the roof of Lykens coal No. 3.

[1] Coal Flora, Vol. III, p. 853.

FLORA OF LYKENS COAL NO. 1.

Lykens coal No. 1, it will be remembered, occurs at about 325 to 360 feet above coal No. 2, and about 250 feet below the "Buck Mountain" coal. The plant association in the roof shale of this, the highest of the Lykens coals worked in this region, is marked, as compared with the flora of the Lykens coal No. 2, by the disappearance of species known to be present in the latter, as well as by the introduction of new forms rapidly approaching the Coal Measures facies. Among the more interesting of the survivors are *Cordaites Robbii*, *Trigonocarpum ampullæforme*, *Whittleseya Campbelli*, and *Carpolithes orizæformis* from the Lower Lykens division, and a form of *Alethopteris Eransii* and *Sphenophyllum bifurcatum* from the Upper Lykens division. An examination of additional collections will no doubt largely increase this number, since it is possible that representatives of all the antecedent Coal Measures types, such as *Alethopteris lonchitica*, *Neuropteris* aff. *heterophylla*, and *N. gigantea*, present in the zone of No. 2 coal, will eventually come to light at the horizon of Lykens coal No. 1. At the same time, however, it is to be expected that the number of new forms will be correspondingly increased.

The forms which have not yet been found below the horizon of No. 1 include *Sphenopteris palmatiloba* var. *squarrosa*, *Neuropteris lunata*, *Annularia cuspidata*, *N. tenuifolia* var. *humilis*, and *N. fimbriata*. The first three of these appear to be characteristic of this zone, while the two last named continue into the Lower Coal Measures. *Annularia cuspidata* is most probably the precursor of *Annularia sphenophylloides*, which appears early in the Allegheny series.

UPPER LYKENS ZONES IN THE TYPE SECTION.

It needs but a glance at the names of the species recorded in the column representing the two approximate beds, H and I, about 550 feet below the Twin coal in the Pottsville Gap, to detect the floral characteristics of the zone of Lykens coals Nos. 2 and 3; while to paleobotanists who are acquainted with the Sewanee flora, whose nearly identical composition has already been noted, the preponderance of common features will at once indicate approximately the same age. The greater portion of the plants recorded from coals Nos. 3 and 2 are also found in the collective material from beds H and I, which have been somewhat thoroughly searched. It will also be observed that besides several new species, such as *Sphenopteris simulans*, *Callipteridium suspectum*, and *Whittleseya Lesquereuxiana*, not found elsewhere, we have *Cordaites angustifolius* and *Cardiocarpon minus*, which are not reported from the vicinity of Lincoln.

Above the trolley road, on the east side of the gap at Pottsville, about 465 feet below the Twin coal, a drift has been driven some

distance along a thin coal, and in dark coaly shales which contain *Mariopteris pygmæa*, *Alethopteris Lacoei*, and *Neuropteris Elrodi* in the facies and association characteristic of the horizon of Lykens coal No. 2 in the Lincoln district, and I have little hesitation in suggesting the probable approximate contemporaneity, if not equivalence, of the two beds.

As previously mentioned, the same horizon appears also to have been touched in a trial shaft on the west slope of Westwood Gap.

Among the more interesting or important additional species in bed J, the probable equivalent of this horizon in the type section in the railroad cut at Pottsville, which has been more thoroughly searched for fossils, are *Eremopteris Aldrichi*, *Sphenopteris palmatiloba*, *S. pilosa*, *Pecopteris serrulata*, *Alethopteris Evansii*, *Callipteridium pottsvillense*, and *Neuropteris hirsutina*. Of these, the first three are usually rather more common at a horizon a little higher than that of coal No. 3 in other coal fields. *Pecopteris serrulata*, which, if the specimen has not been misplaced, occurs in the shales over coal No. 4 at Brookside, has hitherto been unknown at any distance below the zone of coals Nos. 2 and 3. *Callipteridium pottsvillense* is very close to a species from the "coal-bearing shales" of Washington County, Arkansas, where it is associated, as in bed J, with a dilated, thin type derived from *Alethopteris Evansii*. The *Neuropteris hirsutina* is a new species with slender, acute, long-pointed pinnules, strongly suggesting *Neuropteris Scheuchzeri*, to which it appears to sustain an ancestral relation. It is the earliest-known hirsute *Neuropteris*.

The rather small number of plants from bed K is hardly worthy of special consideration, since their source is only about 25 feet higher than J, with whose flora they are in general agreement. It is, however, interesting to note the appearance at this level of an *Eremopteris* (*E. subelegans*) close to *E. elegans*, and a *Sphenopteris* (*S. mixtilis*) probably ancestral to the *S. mixta* of the Coal Measures.

The flora of bed L, about 380 feet below the Twin coal, like that of Lykens coal No. 1, is one of the most interesting in the type section on account of the antecedent Coal Measures forms mingled with typical Pottsville types. In *Calamites Roemeri*, *Whittleseya Campbelli*, and *Carpolithes orizæformis* we seem to have survivors from the Lower Lykens division, though it is possible that the name *Calamites Suckowii* should be substituted for that first mentioned. Omitting the enumeration of other species recorded from the Upper Lykens horizons, at other localities, in the table, it may be observed that, of the species present in bed L, *Eremopteris dissecta*, *Mariopteris Phillipsi*, *Annularia latifolia*, *Bothrodendron arborescens*, *Cordaianthus spicatus*, and *Cardiocarpon annulatum*, characteristic of the Pottsville formation in other regions as well, are unknown in the Lower Coal Measures of the bituminous or anthracite basins of the Northern

States. *Pseudopecopteris obtusiloba* var. *mariopteroides*, *Sphenopteris subpinnatifida*, *Oligocarpia crenulata*, and *Neuropteris tenuifolia* var. *humilis* seem to foreshadow as many Coal Measures types, while *Sphenopteris furcata*, frequently reported in the lower portion of the Lower Coal Measures, is, however, generally more common in the topmost beds of the Pottsville formation. As elsewhere remarked, I have not seen the typical form of *Alethopteris lonchitica* in the Lower Coal Measures of the Northern States; the same may be said of *Trigonocarpum Noeggerathi*. As to whether bed L represents approximately the horizon of Lykens coal No. 1 in the type section, little that is definite can be said. The fact is simply that the flora of each bears nearly the same relation to the older floras, and to those of the Lower Coal Measures, yet there are but few species common to the two. It is not unlikely, however, that the latter circumstance is largely due to the meagerness of the material from the roof of Lykens coal No. 1.

The general biologic evidence, treating the subject from the standpoint of the composition, vertical range, individual relations, etc., of the species, would seem to indicate a similar stage for both. Reasoning from the same evidence, we may conclude that the two beds are referable to horizons not far distant at most. It would also appear slightly more probable that the older terrane may be bed L in the type section. However, very little weight should be attached to so tentative a supposition, even though the latter is supported by the circumstance that the interval between bed L and the Twin coal in the type section is over 375 feet, while Lykens coal No. 1, about 300 feet from the "Buck Mountain" coal, the supposed equivalent of the Twin at Lincoln, approaches within 225 feet of the same horizon at Good Spring. The known variability of the Pottsville terranes is too great to entitle a relative distance of that extent to any serious consideration when the localities are so far removed.

FLORA OF THE UPPER INTERMEDIATE DIVISION.

PLANTS OF BEDS M AND N IN THE TYPE SECTION.

On passing to the consideration of the species in beds M and N of the type section, it is important to bear in mind that the floras of the roof of the upper Lykens coal No. 1, at the Lincoln mine, and of bed L, 380 feet below the Twin coal at Pottsville, are essentially very distinct specifically from the flora of the roof of the "Buck Mountain" (Twin) bed, as will be shown later. The plants of Lykens coal No. 1 and of bed L, which we have tentatively assumed were nearly contemporaneous, are, in fact, characteristic of a zone in the upper part of the Pottsville formation, and are closely bound to the flora of the preceding Lykens coals Nos. 2 and 3, or of beds H, I, and J,

although having little in common with the plant associations of the Lower Lykens division. The small plant collections from the phytiferous terranes in the remaining upper portion of the lithologic type section, which collectively were designated on an earlier page (775) the "Upper Intermediate division," will be found to contain a still larger proportion of Coal Measures species, though yet exhibiting many forms which are common in the beds of supposed Pottsville age in other regions, and which are still unknown in the Lower Coal Measures. The two beds in question are but 35 feet apart, or 245 and 210 feet, respectively, below the Twin coal. They are both, as may be seen by reference to the section, Pl. CLXXXI, intercalated in the massive conglomerates which succeed the great white, egg conglomerate that underlies the south portion of the railroad bridge at the north end of the gap. The conglomerate last mentioned is, on account of its hardness, light color, thickness, and the regularity of its coarse quartz pebbles, one of the most easily recognized beds, lithologically, of the Pottsville formation over a large portion of the Southern Anthracite field. By glancing at the columns of the table showing the species furnished in the small collections, obtained with some difficulty from the coaly or shaly partings between the conglomerates, we find that *Alethopteris Serlii*, *A. coxtoniana*, *Neuropteris ovata*, *N. Desorii?*, *Sphenophyllum cuneifolium*, and *Sigillaria* cf. *levigata* have been obtained from bed M, while *Pseudopecopteris* cf. *squamosa*, *Pecopteris* sp., *Neuropteris ovata*, *Alethopteris Serlii*, *Cardiocarpon elongatum* var. *intermedium*, *C. annulatum*, and, perhaps, *C. bicuspidatum* var. *ohioense* are present in bed N. The last identification is uncertain, since the specimens, which were obtained from coarse, conglomeratic sandstones, are very indistinct and fragmentary. The *Pecopteris* species comprises a villous type close to the ferns described by Professor Lesquereux as *Pecopteris vestita* from the Lower Coal Measures of Missouri, and as *P. Bucklandii* Brongn., from the Pottsville formation at Campbell Ledge, near Pittston, Pennsylvania.

With, perhaps, the exception of the *Alethopteris coxtoniana*, the flora of bed N is apparently as ancient as that of M. The combined list from these two beds, which, on account of their stratigraphic proximity and their similar plant contents, may for the present be treated as one flora, contains but 11 species, yet these are of a highly interesting and suggestive character. But one fern species,[1] *Alethopteris coxtoniana*, is represented in the collections from the Lykens groups. The remaining ferns are either identical with the species of the Lower Coal Measures of the same region, though varying somewhat in minor details, such as size, or are very closely bound to typical Coal Measures species. *Sphenophyllum cuneifolium* is repre-

[1] *Neuropteris ovata* is represented by a variety in the roof of one of the upper Lykens coals at New Lincoln.

sented by the more rigid, coarse-nerved, irregularly dissected, broad-toothed form more characteristic of the Lower Coal Measures; not by the very narrow, lax-leafed type, with thin nerves, described by Lesquereux[1] as *Sphenophyllum saxifragaefolium*, from beds of Upper Lykens age in Washington County, Arkansas. The *Sigillaria laevigata* is at once suggestive of the Coal Measures. The gymnosperms, on the other hand, belong to species which have generally a relatively wide range in the higher part of the Upper Lykens division in other coal fields, and which are hardly known from the Lower Coal Measures of the Northern States. These comprise species that are especially common in the upper portion of the formation, of which *Cardiocarpon annulatum* and *C. bicuspidatum* var. *ohioense* appear to be distinctly characteristic, the former being more restricted to the upper beds.

From the foregoing it appears that in beds M and N we have a flora the pteridophytic elements of which are, on the whole, generally distinct from those characteristic of the preceding zones of the Pottsville formation. The gymnosperms, on the other hand, are characteristic of the Upper Lykens division. Yet the ferns, though identical or closely related to those of the Lower Coal Measures, appear not to exhibit the forms and facies of the species found either in the roof of the Buck Mountain coal (Lower Coal Measures) or in the Brookville or Clarion coals of the Allegheny series, in the bituminous basins of the Northern States. The wide difference between the floras of the preceding zones of the Upper Lykens division of the Pottsville formation, on the one hand, and those of the Lower Coal Measures, on the other hand, has already been indicated, and will be further shown on a later page. Between these two sections—between the flora of Lykens coal No. 1, or of bed L of the type section, and the roof of the Buck Mountain coal, or base of the Lower Coal Measures in the anthracite fields—we have an interval of about 375 feet, within which occurs a very distinct, though perhaps gradual, change from the purely Pottsville plant life to the flora which, as we shall presently see, is distinctly that of the Lower Productive Coal Measures, as that group is recognized in the coal fields of the Northern States. The small collections obtained from the partings, beds M and N, in the upper plexus of massive conglomerates, which occurs within the top of the Pottsville formation as generally defined on a lithologic basis, apparently constitute fragments in evidence of this floral transition. For the present, when speaking of the type section and region, and until the subject is treated in a broader light, in connection with the Pottsville of the other portions of the Appalachian province, I shall continue to use the term "Upper Intermediate division" in referring to this portion of the Pottsville formation.

[1] Coal Flora, Vol. III, p. 726, pl. xciii, fig 9, 9a.

CORRELATIONS.

It is not within the scope of this paper, whose primary purpose is to present a combined stratigraphic and paleontologic type section and definition of the Pottsville flora in the type region, to enter in detail into the subject of the correlation of the various terranes and groups in the Appalachian trough which have been or should be regarded as equivalent to the whole or a part of the Pottsville formation as developed in the Southern Anthracite field. Such a treatment of these extensive and complicated problems can be satisfactorily accomplished only in connection with the consideration of the detailed paleontologic evidence of all the terranes concerned in the comparisons.

In this report questions of contemporaneity will be confined to beds at isolated localities in the anthracite region, or to formations or groups in other regions whose floras are already more or less known, and which will be correlated only in a broad sense.

These cases will be divided into two groups: (1) Detached localities which are situated within the Southern Anthracite field itself and whose actual occurrence in the Pottsville formation in the typical region renders this correlation more important as well as certain, while at the same time adding to our knowledge of the distribution and range of the species in the Pottsville Basin. (2) Terranes or groups whose floras have been studied in other fields.

In discussing the beds of the first category greater confidence will be reposed in the occurrence, in a given bed, of the particular grouping or association of species which, in the beds or sections already discussed, appear to be characteristic of the several horizons, although the number of species from the locality in question may be small. On the other hand, in considering the relative age of formations geographically more remote, greater stress will be laid on the composition of the entire flora, and on the vertical range of its elements as well as the proportion of its identical species.

PALEONTOLOGIC RELATIONS OF COALS DEVELOPED AT ISOLATED MINES IN THE SOUTHERN ANTHRACITE FIELD.

The principal detached localities, within the limits of the Southern Anthracite field, from which fossil plants have been obtained are those inscribed to the right of the columns devoted to the type section in the table of distribution. All of these have at some time been the scenes of coal exploitation or prospecting. In most cases the beds have been either tentatively or definitely, and, as will be further shown, sometimes erroneously, correlated with reference to the Lykens coals mined in the Lincoln-Lykens region. Several of these localities are but a few miles from the mining developments of the latter region, and nearly all are east of the mines. The correlation of these beds, so far as it can

be made with precision or close approximation, has an important bearing on the geographic extent and economic condition of the several coals. With few exceptions the beds discussed are located on the mine maps, while generally they will be found approximately if not exactly identified in the cross-section and columnar-section sheets of the Atlas of the Southern Anthracite Field.

Proceeding along the upturned edge of the coal field in Sharp Mountain, west of Pottsville, we shall consider:

1. *Drifts in the Lower Lykens division in Swatara Gap.* Station 3, Pl. CLXXX. Two of the Pottsville coals have been drifted at a little above water level in this gap. The geographic positions of the openings are shown in mine sheet xvi, Atlas Southern Anthracite Field, Pt. III. The structure of this portion of the basin is illustrated in section 23, cross-section sheet xvi, Atlas Southern Anthracite Field, Pt. VI. From the upper of the coals, which is about 440 feet below the "Buck Mountain" (Twin) coal, as identified by the State survey in this gap, no fossil plants were obtained. The roof shales from the lower coal, mined to a slight extent on both sides of the gap, have furnished species as follows:

Mariopteris pottsvillea.
Neuropteris Pocahontas.
Neuropteris Pocahontas var. inæqualis.
Neuropteris Smithsii.
Whittleseya Campbelli.

These species, though few, are always common in the roof shales of Lykens coal No. 4, of which the first and fourth named are especially characteristic. The inference that this coal, which was mapped by the late State survey as Lykens coal No. 6, is more probably the Lykens coal No. 4, as indicated by the fossils, is further supported by the thickness of the rock (about 600 feet) between it and the Buck Mountain coal. That this coal is as old as Lykens coal No. 6 seems very improbable.

2. *Rausch Gap, Schuylkill County.* Station 4, Pl. CLXXX. At Rausch Gap, 1 mile west of Swatara Gap, two of the Lykens coals have been driven into for some distance. The district is shown on mine sheet xvi, Pt. III of the Atlas of the Southern Anthracite Field. The structure, consisting of a slightly overturned (70° dip) south limb of the deep Coal Measures basin, is similar to that at Swatara Gap. The section at this point, as compiled from the incomplete conglomerate exposures in the gap, is shown in Pl. CLXXXV, Fig. 1.

From the lower of the two coals mentioned, about 975 feet below the representative of the Buck Mountain coal, at the opening on the east side of the gap, there have been gathered the following:

Mariopteris eremopteroides?
Neuropteris Pocahontas var. inæqualis.
Lepidostrobus pennsylvanicus.
Trigonocarpum ampullæforme.

The other coal, about 70 feet higher, opened on the west side, has furnished fragments representing—

Neuropteris Pocahontas var. pentias?
Neuropteris Pocahontas var. inæqualis.
Calamites Roemeri.
Trigonocarpum ampullæforme.
Trigonocarpum Helenæ?

Neither of these florulas is sufficiently complete to form the basis for definite correlation. Nevertheless, not only is it clear that both belong to the Lower Lykens division of the Pottsville formation, but it is also highly probable, from the absence of species characteristic of Lykens coal No. 4, as well as from the presence of *Mariopteris eremopteroides*, and, probably, of *Neuropteris Pocahontas* var. *pentias*, that we have here to do with Lykens coal No. 5, or a still lower coal. As already stated in the discussion of the floral characters of the horizon of Lykens coal No. 6, owing, perhaps, to the scantiness of material in the collections, no definite paleontologic distinctions can yet be drawn between it and coal No. 5. Taking into account the agreement of the florulas with Lykens coals Nos. 5 and 6, as well as the interval between the beds, it seems probable that the coal opened on the west side, which was mapped by the State geologists as Lykens coal No. 6, and correlated by them with the lower bed in the Swatara Gap, is really Lykens coal No. 5, in which case we may assume that the other, lower coal drifted on the east side of the gap represents the Lykens coal No. 6.

The interval between the coals, about 70 feet, as well as the general distances of the latter from the "Buck Mountain" coal, corresponds well with the stratigraphic relations of Lykens coals Nos. 5 and 6 at the Lincoln mine, about 3 miles to the northwest.

Though few in number, the plants in the Rausch Gap, which are distinctly characteristic of the Lower Lykens division, are especially interesting as compared with those from coals that have hitherto been supposed to be of the same age in Lorberry Gap, a mile to the west. The latter will later be especially treated in connection with the Dauphin Basin.

3. *Coal shaft northeast of the North Brookside slope.* At a distance of a little more than 200 yards northeast of the North Brookside slope on Lykens coal No. 2 (Station 7, Pl. CLXXX), a trial shaft was, several years since, sunk on a coal which has been supposed by the local engineers to be the Lykens coal No. 4, though the isolated position of the proving, on the north side of the Wiconisco Basin, opposite Good Spring,[1] left some doubt as to the accuracy of the correlation. The presence of *Mariopteris pottsvillea*, *Sphenopteris patentissima*, *Neuropteris Pocahontas* var. *inæqualis*, and *Neuropteris Smithsii* in the flora from the roof of the coal points clearly to its contemporaneity with the Lykens coal No. 4.

[1] Atlas Southern Anthracite Field, Pt. III, mine sheet xvii.

4. *The Eureka drifts.* Station 33, Pl. CLXXX. The two Eureka drifts or tunnels are, as shown in mine sheet xvi, Atlas Southern Anthracite Field, Pt. III, located on the slope of Broad Mountain, nearly 1½ miles northwest of Tremont. In both the mine map and the cross-section sheet, a portion of which is repeated, with a description, in the Summary Final Report[1] of the State geological survey, the upper Eureka tunnel is represented as starting from near the outcrop of the beds mined in the lower tunnel and traversing a thin relict of the Middle Creek anticline and a narrow basin beyond, so that, at a horizontal distance across the measures of about 375 feet from the coals mined by the lower drift or tunnel, the same coals were again reached and mined on nearly the same south dip (30°–38°). That this interpretation of the structure is almost certainly erroneous will at once be seen on referring to the fossils derived from the two long-abandoned mines.

The plants from the lower tunnel comprise the following species:

Mariopteris pygmæa.
Alethopteris Lacoei.
Callipteridium alleghaniense.
Neuropteris acutimontana?
Calamites approximatus.
Cardiocarpon Cuyahogæ.
Trigonocarpum ampullæforme.
Carpolithes orizæformis.
Whittleseya Campbelli.

This flora, as may be seen by an examination of the chart, is typical of the zone of Lykens coals Nos. 2 and 3, with which the beds in this drift have been correlated by the State geologists. The identity of No. 2 is indicated especially strongly by the presence of the three species first enumerated.

When, however, we examine the roof shales brought from the other (upper) tunnel we find—

Mariopteris pottsvillea.
Neuropteris Pocahontas var. inæqualis.
Neuropteris Smithsii.
Trigonocarpum Helenæ.

This flora, though small, is characteristic of the Lower Lykens division, to which all but *Trigonocarpum Helenæ* exclusively pertain. Furthermore, *Mariopteris pottsvillea* and *Neuropteris Smithsii* are, in the Southern Anthracite field, so far as known, exclusively in or near the horizon of coal No. 4, in which the variety *inæqualis* of *Neuropteris Pocahontas* is at home, while the *Trigonocarpum* is most common at, and essentially typical of, the same level. I have, therefore, little hesitation in referring the horizon of the shales, which are undoubtedly of Lower Lykens age, to the horizon of Lykens coal No. 4.

The shales from a prospect shaft a short distance to the east of the mouth of the upper drift have furnished—

Eremopteris lincolniana.
Eremopteris decipiens.
Alethopteris grandifolia var. obtusa.
Callipteridium alleghaniense.
Neuropteris acutomontana.
Neuropteris tennesseeana.

[1] Vol. III, Pt. I, p. 2120, pl. 384.

The species here associated are all, in general, typical of the zone of Lykens coals Nos. 2 and 3. If the horizon of the shales is on either side of this zone it is perhaps slightly higher. It appears most probable, however, that it is near the outcrop of the neighboring coals Nos. 2 and 3, in agreement with the mapping of the latter on mine sheet xvi of the Anthracite Atlas.

The correlation of the coal mined in the upper Eureka tunnel with Lykens coal No. 4 necessitates a very different structural interpretation of the beds. It strongly suggests a strict and regular parallelism in the same monocline of the coals in both drifts, in which case the interval between coals 3 and 4, about 250 feet, would be entirely in harmony with the corresponding interval, 245 feet, in the Lincoln mine, about 3 miles to the southwest. The Middle Creek anticline seems to have been either erroneously interpreted on the State mine maps as extending too far westward, or, as is quite possible, wrongly platted to the south of the coals in the upper tunnel instead of to the north. Neither the mine map nor the profile appears to contain evidence of importance in contradiction to either alternative.

5. *Valley View colliery, Kohlers Gap.* Station 15, Pl. CLXXX. At the gap in Bear Mountain, 2 miles north of Brookside, several of the Lykens coals have been located, one of the upper Lykens coals being now worked for local use at the Valley View colliery. The position of the developments and the stratigraphic relations of the beds in the north side of the Wiconisco Basin in this region are shown in mine sheet xviii, Atlas Southern Anthracite Field, Pt. III, and in section 26, cross-section sheet xix, Atlas, Pt. VI. The columnar section was described by H. D. Rogers.[1] The species from the heavy, sandy roof shales of the coal, which is mapped as Lykens coal No. 2 in the State mine maps, include among others—

Eremopteris decipiens.
Eremopteris Aldrichi.
Sphenophyllum bifurcatum.
Cordaites Phillipsi.
Cordaites grandifolius?
Cardiocarpon elongatum var. antholithoides.
Cardiocarpon obliquum.

The flora is unlike the floras found in the roof shales of the lower Lykens coals. The distribution of its species is essentially in the Upper Lykens division, and prevailingly in the zone of Lykens coals Nos. 2 and 3, though it appears to lack the species specially characteristic of either coal.

6. *Kemble drift.* Station 16, Pl. CLXXX. The Kemble drift is situated near the western spoon of the Peaked Mountain Basin, on the first of the large, shallow, synclinal, westward-projecting lobes of Broad Mountain. Its position and the general geologic environment are shown in mine sheet xiii, Atlas Southern Anthracite Field, Pt. II, and

[1] Geology of Pennsylvania, 1858, Vol. II, Pt. I, p. 190, Pl. VIII; Lykens coals correlated, by A. DW. Smith, in Summary Final Report, Second Geological Survey of Pennsylvania, Vol. III, Pt. I, p. 2130.

in section 23, cross-section sheet xviii, Atlas, Pt. VI, republished on a small scale, with a brief description, in the Summary Final Report of the late State geological survey.[1] From the rock dump at the mine, which has for many years been operated for country use, the following species were collected:

Mariopteris pottsvillea.
Sphenopteris Lutheriana.
Alethopteris grandifolia.
Neuropteris Pocahontas var. inæqualis.
Neuropteris gigantea var. clavata.
Calamites Roemeri.
Asterophyllites cf. rigidus.
Calamostachys cf. lanceolata.
Sphenophyllum tenue.
Whittleseya Lescuriana.
Whittleseya Campbelli.
Cardiocarpon disculum.
Cardiocarpon obliquum.
Trigonocarpum ampullæforme.
Trigonocarpum ampullæforme var. spectabile.
Trigonocarpum Helenæ.
Trigonocarpum Dawsonianum.
Carpolithes orizæformis.

By far the greater portion of the above names are familiar in the discussions of the floras of the Lower Lykens division. Nearly all the species occur in the shales of that group, while in *Mariopteris pottsvillea*, *Sphenopteris Lutheriana*, and *Sphenophyllum tenue* we seem to have species specially characteristic of Lykens coal No. 4, of which *Neuropteris Pocahontas* var. *inæqualis* and *Trigonocarpum Helenæ* also are largely typical. In fact, in view of the general agreement of the flora as a whole with that of Lykens coal No. 4, and of the presence of several of the species supposed to be typical of that horizon, we may consider the paleontologic evidence as pointing very strongly toward the assignment of the coal at the Kemble drift to an approximate level. As tending, however, to impair the strength of the evidence of these fossils, mention should be made of certain minor differences in the forms of the species. Thus the form of *Mariopteris pottsvillea* present at this mine is a rather lax type with somewhat dilated pinnules, while the form of *Neuropteris Pocahontas* var. *inæqualis* is both elongated and robust. Furthermore, *Alethopteris grandifolia*, *Whittleseya Lescuriana*, and *Cardiocarpon disculum* appear in other portions of the basin to be confined to the zone of Lykens coals Nos. 2 and 3, while *Asterophyllites* cf. *rigidus* is more at home in the upper division of the Pottsville formation. In view of the presence of these elements of generally later age, we may, I believe, safely conclude that the coal mined at the Kemble drift, which is mapped by the State geologists as Lykens No. 5,[2] can not be any older than Lykens coal No. 4. In the Summary Final Report,[3] the correlation of this coal, which is there described as "closely overlain" by coal No. 4, 4 feet thick, is expressed as uncertain. It seems possible that the lower coal is a new one occurring near Lykens coal No. 4, if it

[1] Vol. III, Pt. I, p. 2119, pl. 381.
[2] Atlas Southern Anthracite Field, Pt. II, mine sheet xiii.
[3] Vol. III, Pt. I, p. 2119.

is not, in fact, identical with the latter as mined in the Wiconisco Basin. That the Lykens coal No. 4 probably extends farther to the east on Broad Mountain will be suggested by the flora obtained at the old Altamont colliery No. 1.

7. *Altamont colliery No. 1, near Frackville.* Station 36, Pl. CLXXX. This colliery is situated on the south margin of the New Boston–Gordon Basin at the north border of Broad Mountain, on the northern limit of the Southern Anthracite fields. The areal geology is shown on mine sheet vii, Atlas Southern Anthracite Field, Pt. II. The structure is illustrated in section 17, cross-section sheet v, Atlas, Pt. V, the rock sequence being shown in columnar-section sheet ix, Part IV. As might be inferred from the columnar sections,[1] compiled from diamond-drill bore holes along the basin, the coal was found to be very "faulty," soon pinching too much for profitable mining.

The plants collected at this mine are:

Aneimites pottsvillensis.
Mariopteris pottsvillea.
Sphenopteris asplenioides.
Sphenopteris patentissima.
Alethopteris lonchitica?
Neuropteris Pocahontas var. inæqualis.
Neuropteris Smithsii (form).
Lepidodendron clypeatum.
Lepidostrobus cf. ornatus.
Lepidophyllum quinnimontanum.
Cordaites grandifolius?
Trigonocarpum ampullæforme.
Carpolithes orizæformis.

This flora, even more clearly than that from the Kemble drift, shows a composition distinctly characteristic of the Lower Lykens division, to which is added a small element of younger species. The two floras are of nearly the same general composition and significance, and represent, I believe, approximately, if not identically, the same stage. Therefore, notwithstanding the reported presence of a 4-foot coal, supposed to be Lykens coal No. 4, closely overlying the Kemble drift coal (but one coal appears in this portion of the diamond-drill borings in this vicinity on Broad Mountain), I am strongly disposed to regard the coal here as even slightly younger than, if not really contemporaneous with the Lykens coal No. 4.

It is probable that the same coal, which appears, as will next be shown, also to extend along the southern limb of the Western Middle field to the west of Frackville, is opened at the Gordon incline slope, Moser's drift,[2] and other points on the western lobes of Broad Mountain.

8. *Mount Pisgah, near Mauch Chunk.* Station 40, Pl. CLXXX. From a small drift recently driven on the north slope of Mount Pisgah, not far from the head of the incline of the Switchback Railway, the following species were collected:

Pecopteris serrulata.
Neuropteris sp. indet.
Lepidodendron clypeatum.
Cardiocarpon cornutum?
Cardiocarpon bicuspidatum var. ohioense.

[1] See also Summary Final Report, Vol. III, Pt. I, p. 2080, pl. 367.
[2] Atlas Southern Anthracite Field, Pt. II, mine sheet xiii.

Of these species, *Pecopteris serrulata* and the two Cardiocarpa are, in general, characteristic of and almost exclusively confined to the Upper Lykens division in the Southern Anthracite field and to the upper portion of the Pottsville formation in the bituminous basins. *Lepidodendron dyppeatum*, also, is not generally found in beds below the same division except in the region under consideration. Its typical phase is developed near the base of the Coal Measures. The remaining species of the florula, although represented by material too fragmentary for satisfactory identification, appears to be allied to one of the forms of *Neuropteris* in the upper divisions of the Pottsville, rather than with the small, Callipteridioid, narrow-pinnuled types of the Lower Lykens division. Thus, from the composition and distribution of the flora, it seems probable, notwithstanding the small number of species, that the coal, which is here over 5 feet in thickness, is situated in the Upper Lykens division of the formation.

The geology of this portion of the field is shown on mine sheet i, Atlas Southern Anthracite Field, Pt. I. The structure of the east end of the region is illustrated in section 1, cross-section sheet i of the same atlas. The columnar section of the upper portion of the formation as measured in the Hacklebarney tunnel, about 3 miles distant, shown on columnar-section sheet ii, will, perhaps, serve in a general way to indicate the sequence of terranes at the top of Mount Pisgah, although the coal in question is not identified. If this coal is referable to the Upper Lykens division of the formation, as the fossils seems to indicate, we may conclude either that the Lower Lykens division at the eastern point of the field is much thinner than elsewhere or that the basin which, as mapped by the State survey, extends nearly to the level of the Central Railroad of New Jersey along the Lehigh River is deeper near its extremity than has generally been supposed.

HORIZON OF THE LOWER LYKENS VALLEY COAL IN THE WESTERN MIDDLE ANTHRACITE FIELD BETWEEN FRACKVILLE AND SHAMOKIN.

About 1 mile east of the Altamont No. 1 colliery the Pottsville formation bridges the axis which forms the line of separation between the Southern Anthracite field and the Western Middle Anthracite field, and plunges into the steep Mahanoy Basin east of Mahanoy Plane.

A. For a long distance to the west of Frackville no coal of the Pottsville formation has been worked to any extent, but at the old Gordon (Franklin) mine, in the Western Middle Anthracite field, about 4 miles northwest of the old slope at the Gordon plane, which is within the north border of the Southern field, a coal designated on the mine sheets of the field[1] and in the Summary Final Report of the State

[1] Atlas Western Middle Anthracite Field, Pt. II, mine sheet v; columnar-section sheet ii; Pt. III, cross-section sheets v, vi, section 12.

survey[1] the Lower Lykens Valley coal was formerly worked to a considerable extent. From the rock dump at this mine were obtained the following species, which, though few, appear in the Southern Anthracite field to be either characteristic of or most common in the horizon of Lykens coal No. 4:

Aneimites pottsvillensis.
Neuropteris Pocahontas.
Neuropteris Smithsii.
Lepidodendron clypeatum.
Lepidostrobus pennsylvanicus.
Trigonocarpum Helenæ.

B. At the abandoned Helphenstein colliery,[2] 2 miles south of Locust Gap, there were collected a few species, as follows:

Neuropteris Pocahontas.
Neuropteris Pocahontas var. inæqualis.
Lepidostrobus pennsylvanicus.
Sigillaria sp. cf. dentata.
Trigonocarpum ampullæforme.

C. About 2 miles farther west, along the southern border of the same field, a coal mapped as the same as that wrought at the Gordon and Helphenstein collieries was formerly worked rather extensively by Messrs. Douty and Baumgartner.[3] The species collected from the rock dump are—

Eremopteris sp.
Mariopteris pottsvillea.
Sphenopteris asplenioides.
Neuropteris Pocahontas var. inæqualis.
Neuropteris Smithsii.
Trigonocarpum ampullæforme.
Trigonocarpum Helenæ.
Carpolithes orizæformis.

D. Along the ravine extending up the mountain side above the site of the old Enterprise colliery, a coal supposed to be the same Lower Lykens Valley coal was formerly worked at the Mount Franklin and the Margie Franklin collieries,[4] between which lies a narrow anticline.

From the mine last mentioned the specimens collected include—

Eremopteris sp.
Mariopteris pottsvillea.
Mariopteris cf. tennesseeana.
Sphenopteris asplenioides.
Sphenopteris microcarpa.
Alethopteris protaquilina.
Neuropteris Pocahontas var. inæqualis.
Neuropteris Smithsii.
Lepidodenron alabamense.
Whittleseya Campbelli.
Trigonocarpum ampullæforme.
Carpolithes orizæformis.

A review of the species collected from these mines along the southern border of the Western Middle Anthracite field shows that we have to do with the same flora as that present at Altamont colliery No. 1, within the Southern Anthracite field. In all the collections we find representatives of *Mariopteris pottsvillea*, *Neuropteris Pocahontas* var. *inæqualis*, *Neuropteris Smithsii*, and *Lepidodendron alabamense*, characteristic in the Southern field of the zone of Lykens coal No. 4. The

[1] Vol. III, Pt. I, pp. 2058–2060.
[2] Atlas Western Middle Anthracite Field Pt. II, mine sheet v.
[3] Atlas Western Middle Anthracite Field Pt. II, mine sheet vi.
[4] Atlas Western Middle Anthracite Field, Pt. II, mine sheet vi; Pt. III, cross-section sheets v, vi, section 14.

evidence offered by these species is further strengthened by the presence in the combined flora of the rarer species *Ancimites pottsvillensis* and *Alethopteris protaquilina*, also typical of that level, as well as by *Sphenopteris asplenioides* and *Trigonocarpum Helenæ*, usually found associated with the former in the larger collections. In short, the testimony of the combined flora is so strongly indicative of the contemporaneity of the Lower Lykens Valley coal in this portion of the Western Middle field with Lykens coal No. 4 of the Southern field as to leave little doubt of its approximate synchronism or correlation therewith. The similarity in the stratigraphic position of the coal worked in the Shamokin Gap and at several other points in the western portion of the Western Middle field makes it seem probable that most of the small mines in the Pottsville formation in that region are developed in this coal. No fossils are at hand from the openings in this field on the "upper Lykens Valley" coal, which appears to be thin and unstable.

If the correlations more or less definitely proposed above are accurate, the Lykens coal No. 4 has a relatively wide distribution, not only in the Southern Anthracite field, but also in the Western Middle Anthracite field, and has the greatest extent in workable thickness of all the Lykens coals, though its thickness is generally less than that attained by Lykens coal No. 5 in the Lincoln-Lykens mining district.

ZONES OF THE POTTSVILLE FLORAS IN OTHER REGIONS OF THE APPALACHIAN PROVINCE.

In discussing the distribution of the floras of the several divisions of the Pottsville formation in other basins of the Appalachian province, I shall assume that the dispersion and migration of the species along the shore of the interior Carboniferous sea were, under the favoring conditions of a continuous, broad, base-level coastal-plain shore and currents both strong and varying, so uniform and so rapid as compared with the geologic time required for the sedimentation of the terranes that the similar associations of identical species occurring at different points along the coast are to be regarded as approximately contemporaneous. In other words, when regarding the succession of terranes along the eastern border of the great Appalachian basin, in which we have in different districts the same regular succession of floras, we are justified in considering that beds, along a continuous and uniform coast, containing the same flora are, geologically speaking, synchronous, rather than that we have to do with homotaxy without contemporaneity.

As already remarked, in correlating beds in regions more distant from the locality of the type section, great weight is attached to the composition of the floras and the vertical range of their elements, as well as the proportion of identical species in other basins. Referring to the

paleontologic features of the different coal horizons of the Pottsville formation, as outlined in an earlier part of this report (p. 773), it will be recalled that on the basis of the vertical distribution of the contained floras, so far as they have been brought to light, the formation was divided primarily into (1) a Lower Lykens division, including the roof shales of No. 4 in the mining region and bed D of the type section, and extending downward to the red shale; and (2) an Upper Lykens division, including Lykens coals Nos. 3 and 2 and the roof of Lykens coal No. 1, or beds H to L, inclusive, in the type section. In beds E and F (Pl. CLXXXI) of the type section, comprising what I have designated the Lower Intermediate division, there appears to be some intermingling of the Lower and Upper Lykens species, while in beds about 225 feet below the conventional base of the Lower Coal Measures, or perhaps nearly 100 feet below the paleontologic base, we find another flora of somewhat mixed composition, suggesting the term "Upper Intermediate division." The two intermediate divisions are thin as compared with the whole formation.

Of the two zones in the Lower Lykens division, the lower, including the horizon of Lykens coal No. 5, is characterized by a relatively simple flora. This, as indicated in the discussion of the floras of the several coals, consists principally of *Neuropteris Pocahontas*, which is always present and overwhelmingly abundant, its variety *pentias* being peculiar to this zone. It is also marked by the absence of the forms characteristic of and confined to the upper zone of the division, as the latter is represented in the roof shale of coal No. 4. The plants below coal No. 5, in the basal portion of the formation, are not sufficiently known for the discovery of any special zonal types. No attempt will therefore be made to determine in other regions any equivalents of this basal portion of the section, although certain inferences are unavoidable.

The continued study of the Paleozoic floras along the eastern margin of the Appalachian trough fully confirms the conclusion I stated some years ago,[1] that it is only in the lower portions of the very thick sections of the Pottsville formation in this province that the oldest floras are to be found, and that in general the very thin sections (e. g., along the northern and northwestern margins of the trough) correspond only to the upper portions of the sections of great thickness on the eastern and southeastern shores of the basin. The correlations suggested below will incidentally serve to illustrate this fact. However, since in this report, which is but preliminary to a monograph of the Pottsville flora of the Appalachian province, the correlative significance of the floras will be treated in briefest possible form, without enumeration of the characteristic species or the full presentation of the paleontologic,

[1] Bull. Geol. Soc. America, Vol. VI, 1895, pp. 319–320.

descriptive, and illustrative data, questions of equivalence or contemporaneity will be restricted to a few of the most important and best-known floras. In the later publication it is my intention to discuss the character, range, and sequence of the floras somewhat in detail, and to suggest such correlations of the numerous terranes of the formations, known often under different names in different regions and States, as are indicated by the very voluminous collections in hand, covering both the vertical range and the greater part of the areal extent of the formation in the Appalachian province.

CLARK FORMATION.

In passing from the Southern Anthracite field southward by way of the thinner developments of the Pottsville formation in the Broad Top and Potomac regions, we do not, so far as is at present known, meet with so low a phytiferous horizon as that of Lykens coal No. 5 until we approach the basin of the New River in south-central West Virginia, where within the rapidly deepening sections the Pocahontas and Clark formations appear in the basal portion of the Pottsville formation. Paleontologically, one of the most interesting of the floral zones in this region is that represented by the plants in the roof shales of the Pocahontas coal (360 feet above the Mauch Chunk formation) in the Great Flat Top region of Virginia and West Virginia. In these shales, which comprise the basal portion of the Clark formation, we find a flora containing the greater number of the species found over Lykens coal No. 5 and presenting the precise facies of the latter, including the invariably and almost exclusively abundant *Neuropteris Pocahontas*. The preponderance of identical species, the composition of the flora, and the relations of the latter to the succeeding floras render it certain that the horizon of the flora of Lykens coal No. 5 is, in the great Flat Top region, not far from the Pocahontas coal. The question whether its more precise horizon is above or below the latter coal will be discussed in the monograph, when all the evidence is presented. It may, however, be here stated that it can not be far above the Pocahontas coal, nor is it likely to be over 200 feet below it. The zone of this flora, which has been identified through the Tazewell, Pocahontas, Oceana, and Raleigh quadrangles, might appropriately be designated the *Neuropteris Pocahontas* zone, though in the Virginia region, as in the Southern Anthracite field, varieties of this species are found in higher terranes of the Pottsville formation. This zone includes the basal portions of the Welch formation in the Tazewell quadrangle;[1] the Clark formation in the Pocahontas[2] and Oceana quadrangles; and a portion, above the middle, of a unit which Mr. M. R. Campbell in the manuscript folio relating to the Raleigh quadrangle has named the Thurmond formation.

[1] Geologic Atlas of the United States, folio 44.
[2] Op. cit., folio 26.

QUINNIMONT FORMATION.

The upper portion of the Clark formation, which is about 375 feet thick in the Pocahontas quadrangle, is marked by the enrichment of both the Sphenopterid and Neuropterid groups in the flora. The variety *inæqualis* of *Neuropteris Pocahontas* survives, and in passing upward into the base of the Quinnimont formation, or toward the middle of the Welch formation, the partial contemporary of the Quinnimont, we find it associated with the identical forms of *Aneimites pottsvillensis*, *Mariopteris pottsvillea*, *Sphenopteris patentissima*, *Neuropteris Smithsii*, *Sphenophyllum tenue*, *Lepidodendron alabamense*, and *Trigonocarpum Helenæ*, so common in and characteristic of the horizon of the roof of Lykens coal No. 4 in the Southern Anthracite field. In fact, the flora becomes practically identical with that in the anthracite region. To this zone, for which I have already suggested the term *Mariopteris pottsvillea*, on account of the common occurrence and very easy recognition of the latter therein, belong the fossils from the Dade coal in the Ringgold, Stevenson, and Chattanooga quadrangles[1] and the lower coal mined at Dayton in the Pikeville quadrangle,[2] all in the Tennessee-Alabama region. In fact, to the *Mariopteris pottsvillea* zone, giving the latter a broad interpretation so as to include a series of closely connected modifications of the types, belongs the entire succeeding Quinnimont formation, 300 feet thick in the type region represented in the Pocahontas quadrangle, and present in the Raleigh and Kanawha Falls[3] quadrangles; the upper portion of the Welch formation in the Tazewell quadrangle; a part of the Lookout sandstone, including the vicinity of the Dade coal, in the Chattanooga, Stevenson, Ringgold, Pikeville, and Kingston[4] quadrangles in the southern Appalachian region; and probably a portion at least of the Lee formation in the Estillville, Briceville, Wartburg, and, perhaps, also in the London quadrangles[5] in the northern Tennessee-Kentucky region. The flora of the Hindustan whetstone beds of Orange County, Indiana, is also referable to this zone, and indicates the contemporaneity of those beds with at least some portion of the Quinnimont formation.

The extent of the zones and the more definite relations and equivalents of the formations in the several quadrangles will be discussed in the later, monographic, treatment of the floras.

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[1] Geologic Atlas of the United States, folios 2, 19, and 6, respectively.
[2] Op. cit., folio 21.
[3] Op. cit. These folios have not yet been published or numbered.
[4] Op. cit., folio 4.
[5] Op. cit., folios 12, 33, 40, and 47.

SEWELL FORMATION.

The next higher general flora of marked characters and distinction in either the bituminous or the anthracite regions is that which I have indicated as characteristic of the proximate horizons of coals Nos. 3 and 2 in the Southern Anthracite field. The zone of this flora is characterized by the development of both the Rhacopteroid and the broad-lobed types of Eremopteris; by small, round, and inflated-pinnuled species of Mariopteris; by triangular Alethopterids; by small, palmate-lobed, and Pecopteroid Sphenopterids; by narrow Alethopteroid forms of Neuropteris, such as *N. Schlehani;* by *Megalopteris* species and the Megalopteroid types; by the broad-leaved *Whittleseya*, and by the introduction of the dentate Pecopterids, as well as a great diversity of gymnospermous fruits. The more explicitly distinctive species of the zone of Lykens coals Nos. 3 and 2—*Eremopteris Cheathami* and *E. decipiens*, *Mariopteris pygmæa* of the *M. inflata* group and *M. tennesseana*, *Sphenopteris pilosa* and *S. palmatiloba*, *Alethopteris Eransii*, the Callipteridioid types, *Neuropteris acutimontana* and *N. tennesseana*, *Sphenophyllum cuneifolium* (*saxifragæfolium* form), the Whittleseyas, and many of the fruits—are present in identical forms and associations in the shales over the Sewanee and Sewell coals. In fact, the elements of the flora from Lykens coal No. 3 are so preponderantly identical with those in the roof of the Sewanee coal in Tennessee and the Sewell coal in southern West Virginia that these coals can only be regarded as practically contemporaneous.[1] The paleontologic evidence for the identification of the horizon of the Sewell-Sewanee coals presents the most complete and convincing as well as the most interesting case that has yet come within my observation.

Mariopteris pygmæa and the identical forms of *Alethopteris Lacoei* and *Asterophyllites arkansanus*, which are especially typical of the roof of Lykens coal No. 2 in the Southern Anthracite field, have generally a somewhat higher occurrence and range in the bituminous fields.

The zone of the plants of Lykens coals Nos. 2 and 3, which, in recognition of the long-known flora of the Sewanee coal, at Sewanee and Tracy City, in Tennessee, I have in a previous paper[2] called the Sewanee flora, may be termed the Sewanee zone. The distinctly Sewanee flora is present above the Sewanee coal in the lower part of the Walden formation in the Sewanee,[3] Kingston, Pikeville, and Chattanooga quadrangles of the Tennessee-Alabama region, and over the Sewell coal in the Raleigh, Kanawha Falls, and Hinton quadrangles in West Virginia.

[1] The contemporaneity of the Sewell coal and the Sewanee coal, as well as the similarity of their stratigraphic relations in the Tennessee and Virginia sections, was pointed out in the description of the Pottsville section along New River, West Virginia. Bull. Geol. Soc. America, Vol. VI, p. 316.

[2] Loc. cit.

[3] Geologic Atlas of the United States, folios .

Very nearly contemporaneous with the same flora is that in the roof of the Sharon coal in northwestern Pennsylvania and northern Ohio, partially described by Dr. Newberry in 1872.[1] The "coal-bearing shales" of Washington County, Arkansas, whose species, ranging usually a little higher than those of the Sewanee coal, were described by Professor Lesquereux in his great work on the Coal Flora,[2] can not be of very much later date than the Sewanee coal, and are undoubtedly representative of the Sewell formation.

The lower portions of (*a*) the Sewell formation in the Pocahontas, Raleigh, and Kanawha Falls quadrangles, of (*b*) the Dismal formation in the Tazewell quadrangle, and of (*c*) the Norton formation in the Estillville and Bristol quadrangles, are included in the zone of the Sewanee flora, to which in its broader sense are also referable certain plant-bearing beds of the Briceville formation in the Briceville and Wartburg quadrangles,[3] in Tennessee. It also appears probable that large parts, perhaps the greater portions, of the Pickens and Blackwater formations in the Buckhannon and Piedmont quadrangles,[4] respectively, in West Virginia, are referable to the Sewell formation and are included within the Sewanee zone. However, the question of the existence of the lower horizons of the Pottsville in the relatively thinner sections in the Potomac region will receive particular attention in the later and more complete report.

LOOKOUT FORMATION.

In those earlier published folios of the Geologic Atlas of the United States that relate to the Carboniferous formations of the southern Appalachian region the coal-bearing terranes included in the quadrangles are grouped in but two formations, the Lookout (lower) and the Walden (upper). The Lookout extends from the Bangor limestone (Mississippian) to the top of the great Sewanee conglomerate of Safford.[5] The oldest plants I have yet seen from this formation on the east side of the coal field, where it is thickest, are closely related to those from the roof of the Dade coal in northwestern Georgia, and are clearly referable to the *Mariopteris pottsvillea* zone. Whether the basal terranes of the formation in this region are as old as or older than the Pocahontas coal or the Lykens coal No. 5 is still uncertain. It is, however, highly probable that in the region included in the Kingston, Pikeville, Chattanooga, and Ringgold quadrangles the lowest beds of the Lookout are not older than the zone of the Lykens coal No. 5.

[1] Rept. Geol. Survey Ohio, 1873, Vol. I, Pt. II.

[2] Coal Flora, Second Geol. Survey of Pennsylvania, Report P, 3 vols. and atlas, Harrisburg, 1879–1884.

[3] Geologic Atlas of the United States, folios 33 and 40.

[4] Idem, folios 31 and 28.

[5] Geology of Tennessee, 1869, p. 366.

The study of the higher floras of the formation, including that of the Dade coal above referred to in these quadrangles, shows the higher shales of the Lookout, up to, or nearly to, the base of the Sewanee conglomerate, to be referable to the *Mariopteris pottsvillea* zone in its broad sense, and to the Quinnimont formation in the Pocahontas quadrangle. The fossils at the base of the Sewanee conglomerate in Tennessee, and of the Raleigh sandstone, about 100 feet in thickness, in southern West Virginia, show a slight mingling of Sewanee zone species, the flora being comparable to that of beds E and F of the Lower Intermediate division of the Pottsville Gap section. The Sewanee-Sewell or Upper Lykens flora appears immediately above the great conglomerates which comprise the Raleigh sandstone in the Pocahontas, Raleigh, and Kanawha Falls quadrangles in West Virginia, and which complete the Lookout sandstone in the Chattanooga, Pikeville, McMinnville,[1] Kingston, and Sewanee quadrangles in Tennessee and Alabama. The Lookout sandstone of Hayes seems, therefore, to essentially represent both the Lower Lykens division and the Lower Intermediate division of the type section in Pennsylvania, although I am slightly disposed to doubt the presence in the Lookout of beds as old as the lowest at Pottsville. The Sewanee conglomerate at the top of the Lookout formation of Tennessee and its contemporary, the Raleigh sandstone in West Virginia, appear to stand in the same relative position paleontologically to the Lower Lykens division as does the Lower Intermediate division in the Southern Anthracite field, and each similarly seems to fill the time break between the *Mariopteris pottsvillea* zone in its broad (Quinnimont) sense and the Sewanee (Sewell-Lykens coal No. 3) zone.

FAYETTE SANDSTONE.

The characteristic species so well marked in the lower portion of the Sewanee zone become modified in the later portion, while at the same time new forms are introduced, so that in the southern Appalachian region no sharp line will perhaps be drawn between the more restricted zone of the flora and that of the Lykens coal No. 1 or bed L of the section at Pottsville, into which the species in the upper portion of the Sewanee formation, about 400 feet thick in the Kanawha Falls quadrangle, gradually merge. In this quadrangle the horizon of coal No. 1 is certainly close beneath, if not actually within, the Fayette formation, a group of massive sandstones and shales which succeeds the Sewell formation in the vicinity of New River, and completes the Pottsville, as the latter naturally would be and has been defined on the lithologic basis. A flora possibly contemporaneous with that of Lykens coal No. 1 or bed L seems to be

[1] Geologic Atlas of the United States, folio 22.

present near the Gladeville sandstones in the Estillville quadrangle,[1] Virginia-Tennessee region; also in the Breathitt formation in the London quadrangle, Kentucky; and in the Fayette sandstone itself near Zela, in the Nicholas quadrangle in West Virginia. The Mercer coals of northwestern Pennsylvania are possibly near the same horizon.

CAMPBELL LEDGE, NORTHERN ANTHRACITE FIELD.

The dark plant-bearing shales which lie within a few feet[2] of the supposed representative of the Mauch Chunk (No. XI) in the very thin section (56 feet, more or less) of the Pottsville formation at Campbell Ledge, near Pittston, Pennsylvania, contain a large flora,[3] which can not be older than Lykens coal No. 1 or bed L, and which has so much in common with beds M and N (Upper Intermediate division) of the type section at Pottsville as to strongly argue for a reference to the same time interval.

The question of the equivalence in the southern and central Appalachian regions of the Upper Intermediate division, including the uppermost 300 feet of the type section, involves a both complicated and difficult problem, which, on account of the great expansion of the terranes representing this period as we pass from Sutton in central West Virginia southward, can not be appropriately discussed without a careful presentation of the accompanying paleontologic evidence. Omitting all the details relating to this question, which will receive special consideration in a later paper,[4] it may suffice to say that in the southern Virginia region the time interval, which is represented by 250 to 300 feet of beds, consisting chiefly of the upper plexus of conglomerates, between Lykens coal No. 1 or bed L and the Twin coal in the Southern Anthracite field, appears, as indicated by the fossil plants, to measure over 800 feet of strata on the Kanawha River. It includes the lower half or "group" of the Kanawha formation. Within the lower portion of this interval, which is less argillaceous, there occurs a more gradual transition from the flora at the top of the Sewanee zone, or that of Lykens coal No. 1, to the typical flora of the Lower Kanawha group. The flora first recognized in the Brookville and Clarion horizons of the Northern Bituminous basins, or coal A at Tamaqua and the Twin seam in the Southern Anthracite field, does not appear in the Kanawha region until later Kanawha time. In the lower portion of the Kanawha formation the flora agrees exactly in characters with that of the Lower Coal Measures of the British coal fields, or the greater portion of the Westphalian in continental Europe.[5] In this

[1] Geologic Atlas of the United States, folio 12.
[2] I. C. White, Rept. Geol. Survey of Pennsylvania, G7, p. 143.
[3] Lesquereux, Coal Flora, Vol. III, pp. 855–856.
[4] Bull. Geol. Soc. America, Vol. XI, pp. 145–178.
[5] Loc. cit., p. 167.

connection it should be recollected that the flora of the lower portion of our Lower Coal Measures (Allegheny series), as, for example, at Mazon Creek, Illinois, or Henry County, Missouri, is generally recognized as referable to the Middle Coal Measures, or as near the base of the Upper Coal Measures of Europe.

RELATIVE HORIZONS OF THE BASAL BEDS OF THE THIN SECTIONS AS COMPARED TO THE THICK EASTERN SECTIONS.

So far as the examination of the phytiferous beds in the Pottsville formation has extended, it appears that only the lowest beds of the formation in the Virginia region, where the formation attains a thickness of perhaps 2,500 feet, contain plants of greater antiquity than those of the lower beds in the Lower Lykens division of the type section. It is even possible that the oldest plants in the basal portion of the formation of Virginia are not of earlier date than those in the topmost red shale at the Pottsville and Westwood gaps. Further study is needed to determine this question. The oldest plants that have yet been found in the Lookout sandstone seem to be of later age than the Pocahontas coal, and to be referable to the *Mariopteris pottsvillea* zone. Beds possibly referable to the same zone appear to lie close to the red shale in the Pickens formation, in the Buckhannon quadrangle, in central West Virginia; and the lowest beds of the Pottsville, which is 270 feet in thickness,[1] at Hanging Rock, near Ironton, on the Ohio River, at the western margin of the Appalachian trough, are perhaps referable to the uppermost part of the same zone. North of these points the sections of the Pottsville formation seldom exceed 400 feet, and throughout the bituminous sections of Pennsylvania they are in most cases less than 300 feet in thickness, while in some cases they are less than 150 feet. In none of these sections have I yet found plants older than the upper beds of the Quinnimont formation. No phytiferous beds so low as the Lykens coal No. 4, in the *Mariopteris pottsvillea* zone, have yet come to light. On the other hand, the flora of the Sharon coal, which, along the northern margin of the Appalachian trough, is separated from the marine Lower Carboniferous by a conglomerate, and which at a few points seems to rest directly upon the Shenango shales, is, as has already been pointed out, accompanied by the Sewanee flora. The base of the Pottsville at Bernice, Sullivan County, Pennsylvania, where the formation is probably less than 100 feet thick, is apparently higher than the Sharon coal, while the lowest coal, within 20 feet of the red shale in the Mehoopany Basin in Wyoming County, Pennsylvania, is clearly within the Sewanee zone.

The measurements of the Pottsville at Campbell Ledge, in the

[1] I. C. White, Bull. U. S. Geol. Survey No. 65, p. 193.

Susquehanna Gap through the north wall of the Northern Anthracite field, seem to vary according to the horizon adopted as the upper limit of the formation at that point. But whatever the thickness of the formation, it is certain that the plant-bearing shales beneath the main conglomerate and within 20 feet of the supposed representative of the Mauch Chunk formation are younger than the zone of Lykens coals Nos. 3 and 2, and it is very probable that they are higher than Lykens coal No. 1 or bed L in the type section. In short, although these sections vary greatly by the expansion of the different divisions, there can be no doubt that, generally speaking, the thin sections of the Pottsville formation in the bituminous basins in Pennsylvania and Ohio, or along the western margin of the Appalachian trough in Tennessee and Kentucky, contain only the younger beds of the formation, the oldest beds of which appear to be present only in the deepest sections along the eastern margin of the trough in the Virginia region and in the Southern Anthracite field.[1]

The existence of the older floras in the lower portions only of the thick sections, or, in other words, the equivalence of the very thin sections to the upper portions only of the very thick sections, suggests alternative hypotheses in explanation of the conditions attending the sedimentation of the Pottsville formation. First, the lower portions of the very thick sections may be regarded as laid down in Mauch Chunk time and contemporaneous with the latest red shale or other Lower Carboniferous sediments in other regions, in which case the basal boundary of the Pottsville in those regions may be diagonal in time without unconformity. The second hypothesis assumes a case of overlap, by which the upper and relatively thinner northern and western deposits were spread beyond the limits of the deeper eastern basins in which the thicker deposits were accumulated. In the latter case the unconformity may or may not extend throughout the field.

At present we have no conclusive proof that the oldest Pottsville beds are synchronous with any portion of the marine Lower Carboniferous. This does not of itself, however, necessarily preclude the possibility, or even the probability, of a partial contemporaneity, since the conditions governing the deposition of the typical Pottsville sediments were those directly or indirectly causing the expulsion from the same region of the Lower Carboniferous faunas and promoting the introduction of the earliest Coal Measures invertebrate types. Moreover, the upper red shales of the Mauch Chunk formation in the anthracite regions are almost entirely destitute of marine molluscan fossils. Evidence in proof of such contemporaneity

[1] The lower horizons of the extraordinarily thick section of the Pottsville formation in Alabama have not been paleontologically studied. It is not, therefore, known whether the oldest floras of the Flat Top coal field or of the Southern Anthracite field are present in the lower part of the section in Alabama.

may be sought in the Mississippian regions, whence the slight indications at present in hand have been derived.

Distinct proof of unconformity between the Pottsville and the Mauch Chunk formations is almost unknown in the anthracite fields, except beneath the thin sections of the Pottsville in the Northern Anthracite coal field. Still, such an unconformity has generally been supposed to exist throughout the greater part of the extent of the formation. It must be admitted that the existence of the thick transition series throughout the central portion of the Southern Anthracite field is opposed to such a lack of continuity of the Mauch Chunk and the Pottsville, notwithstanding the large number of local irregularities, such as those indicated in the section, Pl. CLXXXII, all of which may be explained by shifting current action. My own observation in the Northern field convinces me of the discordant relations of the two formations, the lower of which, though very well developed on the eastern border, appears to be almost extinguished beneath Campbell Ledge, on the western margin, less than 5 miles distant. The discordance is frequently observable beneath the thin developments of the Pottsville formation in the more northern and western regions of the Appalachian province. Nevertheless, I hesitate to agree with those geologists who believe the unconformity to exist even beneath the thickest sections of the Pottsville. Such a conclusion seems to be dependent on the still prevalent hypothesis of the absolute time equivalence of the entire Pottsville in all sections and all regions.

For my own part I am slightly inclined to regard the lowest beds of the formation in the deepest sections, such as that in the Flat Top region in Virginia and West Virginia, in which the transition series is not conglomeratic, or that in the Southern Anthracite field, which is conspicuously conglomeratic, as continuous with the Mauch Chunk formation, with whose latest typical sediments in other regions the oldest Pottsville beds may be contemporaneous. From such a beginning the formation expanded to an enormous thickness of materials, supplied, for the most part, through the transportative agency of destructive wave and current action directed against not very distant coastal plain detrital accumulations, under the favoring conditions of a general, though frequently interrupted, submergence. Brief periods of stability or even slight reactive uplifts, in conjunction with bar-forming currents, may have assisted in producing lagoons, coastal swamps, or other conditions suited either to the accumulation of vegetable matter or to the deposition of thin beds of argillaceous material, while at the same time affording opportunities for the further extension of the frontal submarine Pottsville shelf. The gradual, though intermittent, subsidence of the bottom, which made possible the continued piling up of Pottsville strata over broad areas in these regions, while for a time marginal portions of the Mauch Chunk were

yet subject to erosion in other areas, eventually resulted in the submergence of those portions of the coast where thinner Pottsville sections are now found, each of which contains its own paleontologic records marking the time of the submergence of that locality.

The relatively later ages of the lower beds of the Pottsville sections which we meet in approaching the northern and western margins of the Appalachian coal fields constitute conclusive evidence of the westward and northward transgression of the Carboniferous sea during Pottsville time.

UPPER LIMIT OF THE POTTSVILLE FORMATION.

THE FLORA AT THE BASE OF THE LOWER COAL MEASURES IN THE SOUTHERN ANTHRACITE FIELD.

As may readily be inferred from an examination of the columnar sections of the Coal Measures of the Southern Anthracite field, as developed, for example, in the Tremont-Lincoln district,[1] the alternation of conglomerates is so continuous from the typical "Seral conglomerate" into the Lower Coal Measures that it was found in general to be "impossible to assign a well-defined permanent horizon of separation" between the two formations. Not only are the sandstones exceedingly variable as to their thickness and limits, but their uncertain and often indefinite exposures poorly serve the needs of precise delimitation, such as is required for a detailed instrumental mineral survey. Accordingly, for reasons of expediency and necessity, the boundary was arbitrarily fixed by Rogers "at the bottom of the first or lowest considerable coal seam."[2] Under the more refined and exact methods of the succeeding geologists, who have made thorough examination of the region by the aid of abundant prospecting, the position of the lowest workable coal, or its supposed equivalent, has been locally ascertained throughout the greater portion of the field, and the correlations have been extended also to the Middle Anthracite fields.[3]

The practicability of this method is largely due to the occurrence of a coal generally of workable thickness over the greater portion of the fields not far above the great plexus of conglomerate plates at the top of the series. However, as may be supposed, where several thin coals are present in a given section between the lowest workable coal and the main conglomerates of the Pottsville, or where of several thin coals none is workable, the boundary is uncertain. In general, and especially in the central portion of the field, including the vicinity of the type section, it is possible to trace the Twin coal, adopted by

[1] Atlas Southern Anthracite Field, Pt. IVB, columnar-section sheet x; also Pt. II, columnar-section sheet vi; and Pt. I, columnar-section sheet i.

[2] Geol. Pennsylvania, Vol. II, Pt. I, 1858, p. 17.

[3] Ann. Rept. Geol. Survey Pennsylvania, 1886, Pt. III, p. 932; Summary Final Report, Vol. III, Pt. I, pp. 1854, 1920.

Rogers, for a long distance. It is probable that the errors, which undoubtedly exist, in the identification of this horizon in the more distant portions of the field fall within a vertical distance of 100 feet, except in the Dauphin Basin, which will be specially considered in a later section. As to the correlation of the A coal at Locust Gap, north of Tamaqua, there is still a difference of opinion; and again, in the western portion of the Wiconisco Basin, the place of the Buck Mountain coal is a matter of speculation.

The probable approximate position of the Twin coal, which has been agreed upon by all the State geologists who have worked in this region as the equivalent of the Buck Mountain coal, along Sharp Mountain throughout the central portion of the field, to which for the present we shall confine ourselves, is shown in mine sheets xiv, xiv*a*, xv, and xvi, in the third part of the Atlas of the Southern Anthracite Field.

FLORA IN THE ROOF SHALES OF THE TWIN COAL.

Since the floor of the Buck Mountain coal, or its supposed equivalent, the Twin coal, forms the arbitrary line between the Pottsville formation and the succeeding Coal Measures, the flora in the roof shales of this coal may be regarded as representing the basal horizon of the Lower Coal Measures.[1] It therefore marks the upper limit of the Pottsville, as that formation has, so far as I can learn, been defined, with reference to the type section, by the various geologists of the State. The localities whose plants are listed below are all mines or drifts, chosen from the central regions of the field, between the Pottsville Gap on the east and Tremont on the west. Over these the Twin coal has been probably correctly recognized, it being of good body and quality over much of this territory.

(A) Pottsville Gap: Station 1, Pl. CLXXX.[2] From the Twin coal, whose position in the type section is illustrated in Pl. CLXXXI, were obtained the following species:[3]

Pecopteris dentata Brongn.
Pecopteris arguta Sternb.
Pecopteris unita Brongn.
Pecopteris Candolliana Brongn.
Pecopteris orecopteridia (Schloth.) Sternb.
Pecopteris Miltoni Artis.
Neuropteris Scheuchzeri Hoffm.
Annularia stellata (Schloth.) Wood.
Sphenophyllum emarginatum Brongn.
Lepidodendron sp. indet.
Sigillaria tessellata (Steinh.) Brongn.

(B) Swatara Gap: Station 3, Pl. CLXXX. In this gap the Twin coal was formerly mined on both sides, the more extensive operation

[1] Rogers, Geol. Pennsylvania, Vol. II, Pt. I, p. 140.

[2] Atlas Southern Anthracite Field, Pt. II, mine sheets xiv, xiva.

[3] It should be distinctly understood that the identifications on which are based the following lists of species from the Productive Coal Measures in the Southern Anthracite field are merely temporary and provisional. As such they are subject to revision. Most of the names here given may be interpreted as designating the same forms to which they were applied by Professor Lesquereux.

being at Houser's drift,[1] on the east side. The following species were collected from this drift.

Mariopteris muricata (Schloth.) Zeill. var. nervosa (Brongn.) Kidst.
Mariopteris Sillimanni (Brongn.).
Pseudopecopteris squamosa (Lx.).
Pseudopecopteris obtusiloba (Brongn.) Lx.
Sphenopteris cf. nummularia Gutb.
Pecopteris pennæformis [Lx.].
Pecopteris villosa Brongn.?
Alethopteris aquilina (Brongn.) Goepp.
Odontopteris cf. osmundæformis (Schloth.) Zeill.?
Neuropteris ovata Hoffm.
Neuropteris plicata [Lx.].
Neuropteris vermicularis Lx.
Neuropteris capitata Lx.
Neuropteris fimbriata Lx.
Neuropteris Scheuchzeri Hoffm.
Calamites Cistii Brongn.
Sphenophyllum emarginatum Brongn.
Lycopodites uncinnatus Schimp.
Lepidodendron sp. indet.
Lepidostrobus cf. variabilis L. & H.
Lepidostrobus cf. Geinitzii Schimp.
Lepidophyllum cultriforme Lx.
Lepidophyllum oblongifolium Lx.
Lepidocystis quadrangularis Lx.
Sigillaria cf. Brardii Brongn.
Trigonocarpum olivæforme L. & H.?
Rhabdocarpos sp.
Carpolithes transsectus Lx.

(C) Middle Creek: Station 34, Pl. CLXXX. Along the ravine above the Middle Creek colliery a coal said to be the Buck Mountain bed is opened on both sides of the Middle Creek anticline by drifts,[2] from which were gathered the following:

Mariopteris Sillimanni (Brongn.).
Pseudopecopteris squamosa (Lx.).
Sphenopteris mixta Schimp.?
Sphenopteris suspecta D. W.
Oligocarpia cf. Brongniarti Stur.
Pecopteris dentata Brongn.
Pecopteris unita Brongn.
Pecopteris villosa Brongn.?
Pecopteris oreopteridia (Schloth.) Sternb.
Alethopteris aquilina (Schloth.) Goepp.?
Alethopteris Serlii (Brongn.) Goepp.
Calamites Suckowii Brongn.
Calamites Cistii Brongn.
Annularia stellata (Schloth.) Wood.
Sphenophyllum emarginatum Brongn.
Lepidodendron Brittsii Lx.?
Lepidodendron modulatum Lx.
Lepidostrobus cf. Geinitzii Schimp.
Lepidophyllum oblongifolium Lx.
Lepidophyllum cf. Mansfieldi Lx.
Lepidocystis vesicularis Lx.
Sigillaria tessellata (Steinh.) Brongn.
Cordaicarpon cinctum Lx.
Rhabdocarpos multistriatus (Presl) Lx.
Rhabdocarpos mamillatus Lx.
Carpolithes cf. ellipticus Sternb.

(D) Ebony colliery, north of Newcastle: Station 35, Pl. CLXXX. Along Wolf Creek, near the Ebony colliery, about 4 miles north of Pottsville, the Twin coal occurs in good thickness and is somewhat extensively worked.[3] From the roof shales, taken from the drifts near the Schuylkill River, the following flora was obtained:

Mariopteris sphenopteroides (Lx.) Zeill.
Pseudopecopteris squamosa (Lx.).
Pecopteris villosa Brongn.?
Neuropteris ovata Hoffm.
Neuropteris Scheuchzeri Hoffm.
Cyclocladia sp.
Asterophyllites equisetiformis (Schloth.) Brongn.
Annularia stellata (Schloth.) Wood.
Sphenophyllum fasciculatum (Lx.).
Sphenophyllum emarginatum Brongn.

[1] Atlas Southern Anthracite Field, Pt. III, mine sheet xvi; Final Summary Report, Vol. III, Pt. I, p. 2121.

[2] Idem, Pt. II, mine sheet xiii; Pt. VI, cross-section sheet xiii, section 22, Pt. IV B, columnar-section sheet x, section 4; Final Summary Report, Vol. III, Pt. I, p. 2120.

[3] Idem, Pt. II, mine sheet vi; Pt. V, cross-section sheets v-viii, section 17; Final Summary Report, Vol. III, Pt. I, p. 2083.

(E) Altamont colliery No. 2: Station 37, Pl. CLXXX. On the top of Broad Mountain, between Morea and Frackville, close to the northern edge of the Southern field, near the point where the Pottsville formation bridges the gap between the latter and the Western Middle field, the Buck Mountain and mammoth coals have been mined in a shallow basin at the now abandoned Altamont colliery No. 2.[1] The material from the shafts in the Buck Mountain coal contains the following species:

Mariopteris cf. Sillimanni (Lx.).
Pseudopecopteris squamosa (Lx.).
Neuropteris Scheuchzeri Hoffm.
Annularia stellata (Schloth.) Wood.
Sphenophyllum cuneifolium (Sternb.) Zeill.[2]
Sphenophyllum emarginatum Brongn.
Lepidodendron vestitum Lx.?
Lepidocystis (Sigillariostrobus?) quadrangularis Lx.?

The combined flora from these typical localities of the Twin or Buck Mountain coal is given in the following list:

Mariopteris sphenopteroides (Lx.) Zeill.
Mariopteris muricata (Schloth.) Zeill. var. nervosa (Brongn.) Kidst.
Mariopteris cf. Sillimanni (Brongn.).
Pseudopecopteris squamosa (Lx.).
Pseudopecopteris obtusiloba (Brongn.) Lx.
Sphenopteris pseudomurrayana Lx.?
Sphenopteris nummularia Gutb.?
Sphenopteris (n. sp.?).
Sphenopteris mixta Schimp.
Sphenopteris suspecta D. W.?
Oliogocarpia cf. Brongniarti Stur.
Pecopteris dentata Brongn.
Pecopteris arguta Sternb.
Pecopteris unita Brongn.
Pecopteris villosa Brongn.?
Pecopteris orecopteridia (Schloth.) Sternb.
Pecopteris pennaeformis [Lx.].
Alethopteris aquilina (Schloth.) Goepp.
Alethopteris Serlii (Brongn.) Goepp.
Callipteridium Grandini (Brongn.) Lx.
Neuropteris rarinervis Bunb.
Neuropteris ovata Hoffm.
Neuropteris plicata [Lx.].
Neuropteris capitata Lx.
Neuropteris vermicularis Lx.
Neuropteris fimbriata Lx.
Neuropteris Scheuchzeri Hoffm.
Odontopteris cf. osmundaeformis (Schloth.) Zeill.?
Calamites Suckowii Brongn.
Calamites Cistii Brongn.
Cyclocladia sp.
Asterophyllites equisetiformis (Schloth.) Brongn.
Annularia stellata (Schloth.) Wood.
Sphenophyllum emarginatum Brongn.
Sphenophyllum cuneifolium (Sternb.) Zeill.
Sphenophyllum fasciculatum (Lx.).
Lepidodendron Brittsii Lx.?
Lepidodendron modulatum Lx.?
Lepidodendron vestitum Lx.?
Lepidodendron sp. indet.
Lepidostrobus cf. variabilis L. & H.
Lepidostrobus cf. Geinitzii Schimp.
Lepidophyllum cultriforme Lx.
Lepidophyllum oblongifolium Lx.
Lepidophyllum cf. Mansfieldi Lx.
Lepidophyllum affine Lx.?
Lepidocystis vesicularis Lx.
Lepidocystis (Sigillariostrobus?) quadrangularis Lx.
Sigillaria cf. Brardii Brongn.
Sigillaria tessellata (Steinh.) Brongn.
Trigonocarpum oliveaeforme L. & H.?
Rhabdocarpos sp.
Rhabdocarpos multistriatus (Presl) Lx.
Rhabdocarpos mamillatus Lx.
Cordaicarpon cinctum Lx.
Carpolithes transsectus Lx.
Carpolithes cf. ellipticus Sternb.

[1] Atlas Southern Anthracite Field, Pt. II, mine sheet xiii; Pt. V, cross-section sheets v-viii, section 16; Pt. IV, columnar-section sheet ix; Final Summary Report, Vol. III. Pt. I, p. 2080.

[2] Broad, rigid, thick-nerved type present in the lower portions of the Allegheny series (XIII): Lower Productive Coal Measures.

It will be observed that of the 57 species enumerated above but 9 species, including *Mariopteris nervosa*, *Pseudopecopteris obtusiloba*, *Pseudopecopteris* cf. *squamosa*, *Alethopteris Serlii*, *Neuropteris ovata*, *Neuropteris fimbriata*, *Sphenophyllum cuneifolium*, *Lepidocystis vesicularis*, and *Carpolithes transsectus*, are represented even by varieties among the floras in hand from the Pottsville formation. In fact, it would seem from the examination of the specimens that only 5 of the species, viz, *Alethopteris Serlii*, *Neuropteris ovata*, *Neuropteris fimbriata*, *Lepidocystis vesicularis*, and *Carpolithes transsectus*, are represented in both series by identical forms, as may be noted by reference to the floras of beds L, M, and N. *Mariopteris nervosa*, *Pseudopecopteris obtusiloba*, and *Pseudopecopteris* cf. *squamosa* are found only in new varieties or doubtful forms in the Pottsville, while, as has previously been remarked, *Sphenophyllum cuneifolium* is represented by the broader, more rigid-leaved, and thick-nerved phase characteristic of the Lower Coal Measures. In short, a comparison of the lists shows that less than one-tenth of the ferns are represented by identical forms, both in the basal horizon of the Lower Coal Measures and in the upper phytiferous beds of the Pottsville formation. The species common to both formations are largely present in the upper 300 feet of the type section, i. e., the Upper Intermediate division. It must be evident even to one who is not familiar with Paleozoic fossil plants that the fern flora at the base of the Lower Coal Measures in the anthracite and other northern coal basins is almost totally different from that of the Upper Lykens division of the Pottsville.

That the paleontologic characterization of the Buck Mountain coal is similar in the adjoining territory of the Western Middle Anthracite field is indicated by the following combined list of the floras obtained at the Mahanoy Plane (M); at the Vulcan colliery, 1 mile west of Buck Mountain station (V); at the Buck Mountain mine (B), and from the Big Mine Run colliery, north of Ashland (A), in the latter field.

Pseudopecopteris squamosa (Lx.) (V).
Pseudopecopteris obtusiloba (Brongn.) Lx. (B).
Pecopteris pennæformis [Lx.] (M B).
Pecopteris oreopteridia (Schloth.) Sternb. (V B).
Pecopteris villosa Brongn.? (A).
Alethopteris Serlii (Brongn.) Goepp. (A B).
Callipteridium cf. Grandini (Brongn.) Lx. (B.).
Neuropteris ovata Hoffm. (M B A).
Neuropteris plicata [Lx.] (B A).
Neuropteris vermicularis Lx. (A).
Neuropteris fimbriata Lx. (B).
Neuropteris Scheuchzeri Hoffm. (A M).
Annularia stellata (Schloth.) Wood (B).
Sphenophyllum emarginatum Brongn. (V B).
Lepidodendron aculeatum Sternb. (B).
Lepidophyllum lanceolatum L. & H.? (B).

(F) Toward the eastern end of the Southern Anthracite field, in the Sharp Mountain Gap, south of Tamaqua:[1] Station 39, Pl. CLXXX.

[1]Atlas Southern Anthracite Field, Pt. I, mine sheet iii; Pt. II, mine sheet iv; Pt. I, cross-section sheet iii, section 12; Pt. I, columnar-section sheet ii, columnar section 49; Summary Final Report, Vol. III, Pt. I, p. 2095.

Here the Twin coal has been apparently definitely identified at about 830 feet above the red shale, and is now being mined. From the roof shales over this coal was obtained a flora whose character will at once be recognized as similar to that contained in the Pottsville-Tremont district:

Eremopteris cf. artemisiæfolia (Sternb.) Schimp.
Pseudopecopteris squamosa (Lx.).
Sphenopteris nummularia Gutb.?
Sphenopteris (n. sp.?).
Pecopteris dentata Brongn.
Pecopteris oreopteridia (Schloth.) Sternb.?
Alethopteris Serlii (Brongn.) Goepp.
Callipteridium Grandini (Brongn.) Lx.
Neuropteris ovata Hoffm.
Calamites Suckowii Brongn.
Calamites Cistii Brongn.
Annularia stellata (Schloth.) Wood.
Sphenophyllum emarginatum Brongn.
Lepidophyllum affine Lx.?
Lepidocystis quadrangularis Lx.[1]

As has already been remarked, some doubt remains as to the indentity of the Twin or Buck Mountain coal in the Locust Gap, in the opposite side of the basin, about a mile and a half north of the last locality. At this point occur two coals, A and B, one or the other of which is supposed to represent the Buck Mountain coal. Coal A (16 feet in thickness), as shown in Pl. CLXXXV, Fig. 2, lies about 750 feet above the red shale. Coal B is reported as 202 feet above A on the west side of the gap, and 260 feet on the east side.[2]

From the roof shales of coal A a small flora was obtained, as follows:

Mariopteris muricata (Schloth.) Zeill. var. nervosa (Brongn.) Kidst.
Sphenopteris pseudomurrayana Lx.?
Neuropteris capitata Lx.
Neuropteris ovata Hoffm.
Pecopteris dentata Brongn.
Alethopteris aquilina (Schloth.) Goepp.

It is obvious that this, like the floras previously enumerated, is a distinctly Coal Measures flora; and I have no hesitation in concluding that the A coal, which has generally been regarded by the geologists who have worked in this region as belonging within the Pottsville formation, is referable rather to the Lower Coal Measures. It is important to mention in this connection that a flora, probably of no earlier age, is also present in the roof of a thin coal about 72 feet below the Twin coal in the type section at Pottsville. The shales at this horizon in the latter locality have not been systematically searched. They are crowded with great numbers of *Neuropteris Scheuchzeri*, among which are present *Neuropteris rarinervis*, and small fragments of *Asterophyllites* cf. *equisetiformis*, thus indicating a Lower Coal Measures age for this bed as well. It has been suggested by Mr. Smith[3] that the A coal, which, at the Nesquehoning railway tunnel, about 9 miles east of Locust Gap, has a thickness of but 1 foot, and which,

[1] Probably a Sigillariostrobus.

[2] Rept. Geol. Survey Pennsylvania, AA, p. 106; Summary Final Report, Vol. III, Pt. I, p. 2095. The interval is also given as but 115 feet by Ashburner in Report A, p. 80.

[3] Summary Final Report, Vol. III, Pt. I, p. 2096.

in one of the collieries a short distance west of the latter gap, was not discovered in a tunnel extending 400 feet below coal B, is in reality only a bottom split of the Buck Mountain coal.

THE PALEONTOLOGIC UPPER LIMIT OF THE POTTSVILLE.

The important fact embodied in the preceding lists of plants from the roof shales of the Twin coal, in both the Southern and the Western Middle Anthracite fields, is that they represent a typical and distinctive Coal Measures flora. The small element that this flora has in common with that of the Pottsville formation comprises species whose precursors, for the most part differing in their forms and phases from the normal types, have made their appearance only toward the close of Pottsville time. Compared, as a whole, with the flora of Lykens coal No. 1, about 300 feet below the Twin bed in the Lincoln region, or bed L, 380 feet below the Twin in the type section, the species of the latter coal are so different as even to suggest the existence of a time break between the intervening beds. As an argument against such a supposition, I have, however, only to cite the plants from beds N and M, whose floras, not less than 210 feet below the Twin coal at Pottsville, clearly presage the development of the Lower Coal Measures plant life by the introduction of a number of Coal Measures types of ferns, notwithstanding the generally stronger paleontologic bond which attaches these beds to the Upper Lykens division of the Pottsville formation. The transition already indicated in beds N and M seems to have been entirely completed within the time represented by the succeeding 200 feet of the section.

It is necessary in this connection to note the relations of the flora of the Twin coal to those of the Lower Coal Measures in other regions. If we compare that flora with those accompanying the lower coals of the Allegheny series[1] in the Northern States, we find that its composition, range, and development point definitely to a level as high as that of the well-known plant beds at Mazon Creek, Illinois; and that the horizon of the Twin coal should be nearly as high as that of the plants described from Henry County, Missouri,[2] and Cannelton, Pennsylvania. Compared with the better-known floras of the anthracite fields, the plants from the coal in question appear to indicate a level certainly not lower than that of coal C in the Northern Anthracite field, while it is perhaps safe to say that they are nearly as young as coal D (the Marey coal) in the vicinity of Pittston.

According to the evidence of the plants, the beds of the basal portion of the Allegheny series, between the top of the Homewood sandstone and the Morris coal at Mazon Creek—an interval, probably including the Brookville coal, between the same sandstone and a level probably as high as the Clarion coal in the bituminous basins of western

[1] Bull. Geol. Soc. America, Vol. XI, p. 149. [2] Mon. U. S. Geol. Survey, Vol. XXXVII.

Pennsylvania—and the terranes extending from coal A to at least as far as coal C in the Northern Anthracite field, were laid down prior to the deposition of the roof shales of the Twin coal.

The examination of the plants from the above-mentioned basal beds of the Allegheny series shows that they constitute a typical Coal Measures flora, with but a small proportion of Pottsville forms, though they lack so high a development of the Pecopteroid group, as well as several other more advanced types which appear in the Kittanning and Buck Mountain coals. The same is true of the flora of coal C in the Northern Anthracite field. In fact, like the flora of coal A at Tamaqua, or like that indicated in the coal 72 feet below the Twin bed in the Pottsville Gap, and that of the lower horizons of the measures in the Northern Anthracite field, the floras of the basal beds of the Allegheny series, which are above the lithologic Pottsville in the bituminous basins, are clearly referable, on paleontologic grounds, to the Lower Coal Measures. In short, the comparative paleontology of the terranes shows (*a*) that, as related to the Coal Measures of other regions of the Appalachian province, or other basins of the world, the flora of the roof of the Twin coal, which has been made the dividing line between the Pottsville formation and the Lower Coal Measures in the Southern Anthracite field, is of a pure and well-advanced Coal Measures type; and (*b*) that its horizon is distinctly above beds, generally of no great thickness in the northern basins, containing floras characteristic of not so high a level, but nevertheless having a composition which is distinct from that of the floras of the Pottsville formation and which is too thoroughly identical with the plant life of the Lower Coal Measures to permit of any other reference.

From the foregoing it appears: First, that the conventional upper limit of the Pottsville formation, in the Southern Anthracite field, is higher than the paleontologic upper limit. Second, that its horizon is also considerably above that of the same boundary as drawn, not only in the bituminous basins, but also in the Northern Anthracite fields. Third, that the paleontologic limit appears, so far as evidence has been obtained, to lie below, though perhaps very near to, the coal at 72 feet below the Twin coal in the type section, and probably above the plant beds 210 feet below the Twin coal. In other words, it also appears that in the type section the paleontologic upper limit of the Pottsville formation lies close within the upper outskirts of the great plexus of conglomerates in which the formation culminates. Thus, the paleontologic limit falls within and near the natural or lithologic limit.

It hardly need be repeated that the A coal at Tamaqua should, according to the evidence of the fossil plants, be included in the Lower Coal Measures, as should, also, the thin bed next below the Twin coal in the type section. It is not impossible that one or the other of these lower coals is the representative of the Scott Steel coal occurring

at Mill Creek Gap, on the north side of the Heckscherville Valley Basin, in which case the latter should be of Coal Measures age rather than Pottsville age, as has generally been assumed. The reference of several of the thin coals not far below the Twin or Buck Mountain horizon to the Lower Coal Measures is not discordant with the opinion that they are but splits from the Buck Mountain bed,[1] though I do not so regard them. It appears more probable, however, that they are distinct and earlier beds, whose geographic extent may not be great, and whose individual correlation, in any event, is uncertain.

The difference between the positions of the conventional formation limit in the Southern as compared with that in the Northern Anthracite field is no doubt due to the continued deposition, with exceedingly slight intermissions, of heavy conglomerates above the main plexus of egg-conglomerates in the Southern Anthracite field, which, in turn, is the result of the nearness of the latter to the abundant and rapid supply of coarse sediments.

LOWER LIMIT OF THE FORMATION.

Owing to the transitional character of the passage beds from the typical red shale of the Mauch Chunk to the typical gray conglomerate phase of the Pottsville, as illustrated in Pl. CLXXXII, the discovery of a constant and recognizable boundary is a much more difficult matter than would at first appear, if indeed it is not an impossibility. Having observed that the upper beds of the red shale are, like the intercalated conglomerates, irregular, unstable, and subject to disappearance by wedging or pinching out,[2] the practice of selecting some arbitrary boundary in the conglomeratic upper portion of the red shale was inaugurated by the first State geological survey, and has been followed by the geologists of the second survey. As the result of this usage in the type region, where the transition is the most gradual, "the fixing of a precise limit between the two formations becomes, in many instances, a matter of individual preference and judgment,"[3] and it follows, not only that the thickness assigned to the sections varies with the geologists, but that it is often necessary to hold the published columnar section in hand in order to find the arbitrary boundary. To this element of uncertainty is probably due a portion of the apparent variations in the recorded thickness of the formation at certain points, as compared to that at other places, since in some sections several hundreds of feet below the topmost red shale have been included in the Pottsville formation, while in other regions the line has been drawn at or near the last stratum of red shale. Fortunately, toward the western end, and along the northern border of the Southern Anthracite

[1] Summary Final Report, Geol. Survey Pennsylvania, Vol. III, Pt. I, p. 2083.
[2] Rogers, Geol. Pennsylvania, Vol. II, Pt. I, pp. 22, 25.
[3] Smith, Summary Final Report, Vol. III, Pt. I, p. 1921.

field, as well as in the other anthracite coal fields, the contact of the Pottsville formation with the Mauch Chunk is very much more sharply defined.

As perhaps the less of two evils, I have adopted the topmost bed of normal red shale in each section as the lower boundary of the Pottsville formation, thus applying the method used under more favorable circumstances by the geologists who have worked in the bituminous regions of Pennsylvania. Though arbitrary and variable, since the topmost beds are possibly in certain cases mere washes or redepositions of the true Mauch Chunk, such a boundary line possesses at least the merit that when once seen it may usually be readily recognized by subsequent visitors to the locality.

The differences in the estimates of thickness, which are largely due to the lack of uniformity in selecting a basal boundary for the Pottsville, will be illustrated in the discussion of the thickness of the formation.

THE POTTSVILLE FORMATION IN THE DAUPHIN BASIN.

Dauphin Basin and Schuylkill-Dauphin Basin are terms applied to the entire south prong of the "fish-tail" in the western portion of the Southern Anthracite field. It is a long, narrow trough extending about 30 miles west from Lorberry Gap to within 1½ miles of the Susquehanna River at Dauphin. From a width of about 1½ miles near the eastern end and of nearly a mile at Rattling Run, over half way toward the western end, it tapers to a narrow, relatively acute apex. Structurally the basin is essentially a simple close fold. The hard conglomerates of the Pottsville formation, which constitute the floor of the field, rise as rim walls on either side of the basin, forming the axes of Stony Mountain, the northern limb of the syncline, and Sharp Mountain, the southern limb. The profound erosion of the thick formation of soft red shales on either side of the basin causes the coal field to stand out topographically as an elevated trough. The beds of the north limb, Stony Mountain, whose crest dips southeast about 70°, are not so steep as those of Sharp Mountain, which, from a nearly vertical attitude in the region of Black Spring Gap, become overturned at Lorberry Gap to a dip of 73° N.

Westward from Black Spring Gap the Pottsville wall declines with gradually lessening dip as we approach the apex of the field. Stony Mountain presents a regular and unbroken crest. Sharp Mountain, on the other hand, is cut by six V-shaped gaps to the west of Lorberry Gap. The softer interior Coal Measures have been gently eroded to form a generally shallow, rounded interior valley in the trough, which is locally more deeply cut, but still broadly rounded, by the work of the small streams which escape through the jaws of Pottsville conglomerate in the gaps. At Big Flats, over 8 miles from the west-

ern apex of the field, Sharp and Stony mountains become confluent by the convex contents of the basin, and from that point westward, as the successive terranes "spoon out," the basin forms a single crest, known as Short Mountain. The topography of the basin is represented on the Pine Grove, Lykens, Hummelstown, and Harrisburg sheets of the Topographic Atlas of the United States.

The areal geology of the region, as shown in mine sheets xxi–xxvii, inclusive, of Pt. III of the Atlas of the Southern Anthracite Field, is essentially correct except as to the mapping of the Pottsville formation, which, as will presently be shown, is, together with the Lykens groups, located quite to the north of the Lykens groups as they actually exist in Sharp Mountain throughout the greater part of the length of the basin. Cross sections are shown on sheet xxi, Atlas Southern Anthracite Field, Pt. V; and several columnar sections, based principally on the work of R. C. Taylor and the first survey, are given on columnar-section sheet viii, Pt. IV B. Descriptions, usually of a fragmentary character, and based chiefly on Taylor's[1] reports of the explorations and developments of the field prior to 1840, are given by Rogers,[2] and in more complete form, with additions derived in part from Taylor's notes, by A. DW. Smith,[3] both of whom reproduce in modified form the sections published by Dr. Taylor.

It is to the southern or Sharp Mountain limb of the basin that the discussion in this paper will, for the most part, be confined. The key to the stratigraphic problem in hand is the Lorberry Gap section, at the eastern extremity of the basin, and this will first be considered.

AGE OF THE COALS IN LORBERRY GAP.

SECTION AT LORBERRY GAP.

(Station 17, Pl. CLXXX.)

On entering upon the study of the plants from the Pottsville formation in the type region, when endeavoring systematically to obtain fossils from the greater number of mines or more important drifts located in different parts of the field, Lorberry Gap, 4 miles south of Tremont and about 2 miles south of the Lincoln mine, was selected as a favorable locality, since in the latest published anthracite mine sheets several of the Lykens coals are represented as mined there. This point was also thought to be especially important, because it appeared to offer good facilities for securing fossils directly from drifts in Lykens coal No. 6, concerning which it is still desirable to obtain more paleontologic data.

[1] Two Reports on the Stony Creek Estate, 1840. See also: Report on the Swatara Mining District, Pennsylvania State legislature, 1839, p. 16, diagram.

[2] Geol. Pennsylvania, Vol. II, Pt. I, pp. 193–198.

[3] Summary Final Report, Vol. III, Pt. 1, p. 241.

The section at Lorberry Gap is described by Rogers and the geologists of the second State survey, on whose mine sheets (xvi and xxi) the coals have ostensibly been traced from Rausch Gap westward. The cross section is given in cross-section sheet xvi, Pt. VI of the Southern Anthracite Field Atlas. These mine sheets are valuable as showing the position and extent of the mine workings, and the dip as well as the direction of the strike of the coals. The topographic features of the district are shown on the Pine Grove sheet, Topographic Atlas of the United States.

Great was my surprise when, on inspecting a collection of plants from the roof shales of the southernmost coal opened in the gap—the bed mapped as Lykens coal No. 6, and apparently lying in the position of that coal with reference to the top of the red shale—I discovered the presence of a distinctively and unmistakably Productive Coal Measures flora, comprising species as follows:

Mariopteris muricata (Schloth.) Zeill. var. nervosa (Brongn.) Kidst.
Pseudopecopteris squamosa (Lx.).
Sphenopteris suspecta D. W.?
Pecopteris aspidioides Sternb.
Pecopteris unita Brongn.
Pecopteris orecopteridia (Schloth.) Sternb.
Pecopteris Miltoni Artis?
Alethopteris pennsylvanica Lx.?
Neuropteris ovata Hoffm.
Neuropteris vermicularis Lx.
Neuropteris fimbriata Lx.
Neuropteris Clarksoni Lx.
Neuropteris Scheuchzeri Hoffm.
Sphenophyllum emarginatum Brongn.
Lepidodendron dichotomum Sternb.
Lepidophyllum oblongifolium Lx.
Rhabdocarpos multistriatus (Presl) Lx.
Rhabdocarpos jacksonensis Lx.?

Search was then made in the shales accompanying the next higher coal, mapped as Lykens coal No. 4, mined both at Molley's slope, within the south end of the gap, and at Yoder's drift. The plants obtained at the slope are:

Mariopteris cf. cordato-ovata (Weiss).
Pecopteris emarginata Goepp.
Pecopteris polymorpha Brongn.
Alethopteris pennsylvanica Lx.?
Callipteridium Grandini (Brongn.) Lx.?
Neuropteris ovata Hoffm.
Neuropteris Scheuchzeri Hoffm.
Asterophyllites equisetiformis (Schloth.) Brongn.
Sphenophyllum emarginatum Brongn.

Those gathered at Yoder's drift include:

Pecopteris emarginata Goepp.
Pecopteris unita Brongn.
Pecopteris lepidorhachis Brongn.?
Pecopteris polymorpha Brongn.
Alethopteris pennsylvanica Lx.?
Neuropteris ovata Hoffm.
Neuropteris Scheuchzeri Hoffm.
Asterophyllites equisetiformis (Schloth.) Brongn.
Annularia ramosa Weiss.
Annularia stellata (Schloth.) Wood.
Sphenophyllum emarginatum Brongn.
Lepidodendron cf. dichotomum Sternb.
Lepidostrobus cf. variabilis L. & H.
Lepidophyllum hastatum Lx.?
Lepidocystis vesicularis Lx.
Sigillaria camptotænia Wood.
Sigillaria cf. alternans Sternb.

The flora of this coal indicates a still higher horizon in the Coal Measures. To this evidence may be added that of the fossils from the mine dump at the south end of the gap, though the latter are less

trustworthy, on account of the liability of transportation along the outlet of the valley. The species are as follows:

Mariopteris sp.
Mariopteris cf. Sillimanni (Lx.).
Sphenopteris sp. (nov.?).
Sphenopteris cristata Brongn.?
Sphenopteris cf. flagellaris Lx.?
Oligocarpia missouriensis D. W.
Aloiopteris serrula (Lx.).
Pecopteris dentata Brongn.?
Pecopteris unita Brongn.
Pecopteris notata Lx.
Pecopteris cf. pusilla Lx.
Pecopteris oreopteridia (Schloth.) Sternb.
Pecopteris polymorpha Brongn.
Alethopteris aquilina (Schloth.) Goepp.
Alethopteris pennsylvanica Lx.
Callipteridium cf. Mansfieldi Lx.
Neuropteris minor Lx.
Neuropteris ovata Hoffm.
Neuropteris vermicularis Lx.
Neuropteris fimbriata Lx.
Neuropteris capitata Lx.
Neuropteris Scheuchzeri Hoffm.
Neuropteris Clarksoni Lx.
Neuropteris inflata Lx.
Neuropteris Desorii Lx.?
Odontopteris sp.
Linopteris obliqua (Bunb.).
Annularia stellata (Schloth.) Wood.
Annularia sphenophylloides (Zenk.) Guth.
Sphenophyllum emarginatum Brongn.
Sphenophyllum cuneifolium (Sternb.) Zeill.?
Lycopodites Erdmanni [Lx.].
Lepidodendron dichotomum Sternb.?
Lepidodendron modulatum Lx.
Lepidostrobus Geinitzii Schimp.?
Lepidophyllum oblongifolium Lx.
Lepidophyllum affine Lx.?
Lepidophyllum majus Brongn.?
Rhabdocarpos multistriatus (Presl) Lx.
Rhabdocarpos jacksonensis Lx.?

A somewhat crude representation of the terranes in the Lorberry Gap including the coals referred to is shown on Pl. CLXXXV, Fig 3. In this section the "South" and "Peacock" coals are those mapped as Lykens coals Nos. 6 and 4, respectively, on the mine sheets.

Since the proximity of the Lower Coal Measures to the red shale clearly indicated the disappearance of a part or the whole of the Pottsville formation by faulting, a stratigraphic study was next made of Sharp Mountain in this district. The results of this examination will be stated only in brief form, since the local stratigraphic conditions are apparent when once the presence of a fault is recognized.

THE FAULT IN SHARP MOUNTAIN.

The section of the Pottsville formation at Rausch Gap, Schuylkill County, shown on Pl. CLXXXV, Fig. 1, has been found to be normal, the formation being about 1,200 feet thick, and the lower coals, discussed on an earlier page, also found to belong to the Lower Lykens group. Proceeding westward from Rausch Gap,[1] which is a little over 1 mile from Lorberry Gap, the protruding edges of the nearly vertical hard conglomerates of the upper part of the formation may be readily traced for a short distance along a sharp knob. However, at about one-third of a mile from the gap the ledges become crushed, and the knob, topographically shown on mine sheet xxi, and on the Pine Grove

[1] This gap must not be confused with that of the same name farther west, along Sharp Mountain, in Lebanon County, or with that in the north side of the Wiconisco Basin, formerly incorrectly designated Klingers Gap, and in a later State report Kohlers Gap.

sheet of the Topographic Atlas of the United States, is somewhat abruptly sheared in a direction apparently N. 15° E. Westward, instead of a dense talus of massive conglomerate bowlders, which never fails to mark the vicinity of the steeply outcropping Pottsville conglomerates, we find a gently rounded, smooth, broad ridge nearly devoid of all talus of a coarse type. Furthermore, over this smooth plateau surface there are scattered a number of prospect shafts, in one of which, less than 100 yards from the crushed ends of the conglomerates, and nearly in the probable strike of the horizon of Lykens coal No. 1, I collected fragments of *Annularia sphenophylloides*, *Sphenophyllum emarginatum*, *Neuropteris orata*, *N. plicata* [Lx.], and fragments apparently referable to *N. Scheuchzeri*, all species clearly indicative of the Productive Coal Measures. On passing southeastward from this point, across the line of displacement, the Mauch Chunk red shale is found in its normal place below the remnant of the lower conglomerates of the Pottsville formation. The line of the fault appears to be marked by a slight diagonal depression, by a zone of ferruginous brown earth, by numerous springs, and by occasional more or less obliquely or irregularly disposed trains of crushed sandstone or conglomerates. Beyond these, to the west, the shale and coal swales, or the trains of thin sandstone talus marking the outcrop of the Coal Measures shales, or of the relatively thin and less coarse Coal Measures conglomerates, may be traced to their more complete exposures and orientation in the upper portion of the Lorberry Gap.

The section shown in Pl. CLXXXV was not instrumentally measured by me, though a tapeline was used; but it shows the approximate relations of the beds exposed on the east side of the Lorberry Gap. The nomenclature of the coals is that found in the early Report on the Swatara Mining District.[1] The coals designated the South coal, the Peacock coal, and the Umbehauer coal are those respectively mapped on mine sheet xxi as Lykens coal No. 6, Lykens coal No. 4, and the Buck Mountain coal.[2]

The mantle of talus from the lower exposures of conglomerate effectually conceals the outcrop of the upper red shales of the Mauch Chunk formation in the immediate vicinity of the gap, though it may be found at some distance to the east as well as to the west of Lorberry Creek. On the mine sheet the boundary of this red shale, which appears to be somewhat hypothetically drawn, is given a gradual swing to the south, on the supposition that there is a gentle flexure of the formations. The nearly vertical ledges displayed at the lower end of the gap and situated below the coal (the South bed) mapped in the Atlas as Lykens No. 6 are successively found, when traced from the gap a very short distance eastward, to be somewhat abruptly transformed

[1] State legislature of Pennsylvania, 1839.

[2] For more exact data as to the intervals of the coals, the reader is referred to the published sections.

into crushed fragmentary talus, and to disappear on approaching the fault line, beyond which we find the ordinary red shale. Similarly, the South coal itself is cut off at a short distance beyond the point, less than 1,000 feet from the gap, where it was abandoned on account of its squeezed condition. The red shale of the Mauch Chunk is exposed 300 feet east of Yoder's drift (1,600 feet from the gap), which is in the next higher exposed coal (Peacock), mapped in the Anthracite Atlas as Lykens No. 4; and it is probable that had the mine gangway, which, in the miners' vernacular, "ended in fault," been driven 250 feet farther, it would have penetrated olive-green and red shales.

From the foregoing details it will be seen that the somewhat oblique fault crossing Sharp Mountain just west of the knob that abuts against Rausch Gap entirely cuts off the Pottsville formation and a portion, at least, of the Lower Coal Measures, so that Coal Measures, probably including the greater portion of the section shown on Pl. CLXXXV, Fig. 3, are thrust past the truncated Pottsville formation, or the red shales, against which the lower coals, carrying fossils clearly typical of the Productive Coal Measures, are found to abut.

The Pottsville, if any part of that formation is present in Lorberry Gap, must lie to the west of that fault and south of the lower coal (South bed) drifted in the gap. The cause of the displacement of the formations between Lorberry and Rausch gaps may perhaps be ascribed to the close group of folds to the north, and more immediately to the pressure-thrust resulting from the Georges Head anticline.

As interesting, as well as corroborative of the evidence of the plants of the lower coals, I may add that the fossils from near the coal mapped as the Buck Mountain bed at the north end of the gap comprise a Coal Measures flora containing *Odontopteris* of the type of *Brardii* and several small Pecopterids indicative of a very high stage in the Coal Measures.

That the strata on the east side of Lorberry Creek are continued on the west is proved by the extension of the lower levels in the Peacock and Umbehauer beds beneath the creek and for some distance beyond, one of the gangways in the higher coal having been driven nearly 1,500 feet west of the creek. The strike of the coal is nearly parallel to that of the crest of the mountain. The continuity of the series on the west side is also shown in a general way by the fossil plants. Thus the flora from the rock dump at the south end on the west side of the gap may also be cited in evidence:

Mariopteris cf. cordato-ovata (Weiss).
Pecopteris unita Brongn.
Pecopteris emarginata Goepp.
Pecopteris polymorpha Brongn.
Alethopteris pennsylvanica Lx.?
Neuropteris ovata Hoffm.
Neuropteris vermicularis Lx.
Neuropteris fimbriata Lx.
Neuropteris Clarksoni Lx.
Neuropteris Scheuchzeri Hoffm.
Annularia stellata (Schloth.) Wood.
Sphenophyllum emarginatum Brongn.
Lepidodendron sp. indet.
Lepidophyllum oblongifolium Lx.

To the latter may also be added the following species from a coal, probably the Peacock, on the west side, i. e., the coal mined at the Molley slope, and Yoder's drift on the east side of the gap, and mapped as Lykens coal No. 4:

Pecopteris pteroides Brongn.
Pecopteris polymorpha Brongn.
Neuropteris Scheuchzeri Hoffm.
Calamites Cistii Brongn.
Sigillaria camptotænia Wood.

The shales from the second coal, nearly 390 feet above the Peacock coal, are filled with *Annularia stellata*, *Pecopteris unita*, and vast quantities of *Pecopteris aborescens*. The plants in the shales over the individual coals of the Productive Coal Measures of the Southern Anthracite field have not yet been studied systematically and from a stratigraphic standpoint. No attempt will, therefore, at present be made to correlate the Lower Coal Measures in Lorberry Gap by means of fossils.

The conglomerates in the lower part of Lorberry Gap may easily be traced through the greater part of the distance across to Fishing Creek Gap, 2½ miles to the west, but owing to the subsidence of the crest in a broad and rounded ridge slope the individual beds can not be traced quite to the Fishing Creek Gap without the aid of a careful instrumental survey. The late State geological survey has indicated the approximate outcrop of the lower coal of Lorberry Gap as gradually diverging slightly from the crest beyond a point 1 mile west of Lorberry Gap, and as passing just south of the little knob facing Fishing Creek Gap. The boundary of the red shale was evidently thought to be necessarily parallel with that of the coal, and we find it thus traced on the mine sheet.

SECTION AT FISHING CREEK GAP.

(STATION 18, PL. CLXXX.)

No detailed description of the section in Fishing Creek Gap appears to have been published. The geographic position of the three coals opened toward the lower end of the gap is shown in mine sheet xxi, Atlas Southern Anthracite Field, Pt. III.

In this map the lower coal is correlated with the lower coal (South) mined at Lorberry Gap, and the approximate outcrop of this supposed Lykens coal No. 6 is traced between the drifts in the two gaps. The upper coal (Peacock) is likewise mapped as Lykens No. 4, just as in the eastern gap. The relations of these lower coals to the outcropping sandstones in Fishing Creek Gap are shown in the section, Pl. CLXXXVI, Fig. 1, the position of the red shale being recorded as it appears, immediately on the east side of the gap, which, indeed, the section represents, the upper coal being projected from the west side. It will be observed from both the topography, which is low on the east, and from the columnar section, that the conglomerates are neither

heavy nor numerous. The reason for this fact will appear upon an examination of the fossils obtained at the south drifts. The flora collected from the lower drift, the supposed Lykens No. 6, on the east side, includes:

Sphenopteris cf. mixta Schimp.
Oligocarpia cf. Brongniarti Stur?
Pecopteris pusilla Lx.
Pecopteris unita Brongn.
Pecopteris Miltoni Artis.
Pecopteris polymorpha Brongn.
Neuropteris ovata Hoffm.
Annularia stellata (Schloth.) Wood.

That from the drift, about 50 feet higher on the same side, reveals:

Mariopteris cf. cordato-ovata (Weiss).
Pecopteris oreopteridia (Schloth.) Sternb.
Pecopteris arborescens (Schloth.) Brongn.
Alethopteris pennsylvanica Lx.?
Neuropteris ovata Hoffm.
Neuropteris plicata [Lx.].
Neuropteris Clarksoni Lx.
Neuropteris Scheuchzeri Hoffm.
Calamites Suckowii Brongn.

Sphenopteris pinnatifida (Lx.), *S.* cf. *Gravenhorstii* Brongn., and *Cordaites serpens* Lx. are additional species gathered from the rock dump, which may contain shale from both drifts.

The similarity of this flora to the floras listed from the Twin coal (Buck Mountain bed), in the central portion of the Southern Anthracite field, or to the flora of the lower coal in Lorberry Gap, is at once apparent. It, like those considered, is a pure Coal Measures flora.

WESTERN LIMIT OF THE FAULT.

It will be observed that the red shale is shown in Pl. CLXXXVI, Fig. 1, as but 247 feet below the lower coal on the east side of the gap. It is not wholly improbable that the Mauch Chunk formation approaches along the line to the east of the section, even to within 120 feet of the coal. Unless the red shales in the old clearing, about 350 feet to the east of the gap, have been transported by human agency, as seems rather improbable under the local conditions, the Mauch Chunk lies at that point within 100 feet of the lower coal drifted in the gap.

As lending color of probability to the assumption of the existence of such a diagonal contact of the two formations, I will add that along the wagon road on the west side, below the gap, I have not seen the red shale above a point about 700 feet below the lower coal mined in the gap; this point is about 155 feet south of the forks in the wagon road. I do not, however, question the correctness in this respect of the mine map on which the shale is platted as nearly 140 feet north of the same road forks. To the west, and for a short distance to the north of this exposure, a zone of dark-brown ferruginous soil, accompanied by springs, extends in a direction apparently SSW. To the east of this zone no heavy conglomerates are seen in place, though the brown tract is strewn with loose blocks from the hillside on the west. This zone I believe to be along or near the fault line.

The most important fact, however, in connection with the trend of the fault at Fishing Creek Gap is the existence, at a short distance west of this brown zone and along the upper part of the mountain slope, of the characteristic shoulders, benches, and dense talus trains of fragments of the massive Pottsville conglomerates. The entire thickness of the formation seems to have appeared opposite the first knob, at but a short distance west of the Fishing Creek Gap. The more northern outcropping of the red shale on the east of the gap is quite in harmony with the apparently diagonal trend of the fault.

That the Lower Coal Measures are continuous across the gap in the vicinity of the mine drifts is shown not only by the alignment of the coal horizons and sandstones, but also by the character of the fossils. Those collected from the lower coal on the west side are:

Pecopteris polymorpha Brongn.
Dadoxites sp.
Alethopteris pennsylvanica Lx.?
Neuropteris ovata Hoffm.
Neuropteris Scheuchzeri Hoffm.
Calamites Cistii Brongn.

It should be recalled that *Pecopteris polymorpha* is not known in the lower coals of the Lower Coal Measures, either in the bituminous basins or in the Northern Anthracite field.

The species from the upper coal, about 170 feet higher, mapped as Lykens coal No. 4, on the west side of the gap are:

Pecopteris unita Brongn (cf. Newberryi F. & W.).
Pecopteris orecopteridia (Schloth.) Sternb.
Neuropteris ovata Hoffm.
Neuropteris fimbriata Lx.
Linopteris obliqua (Bumb.) Pot.
Annularia stellata (Schloth.) Wood.

Pecopteris unita is an exclusively Coal Measures species, while *Neuropteris ovata* and *Neuropteris fimbriata* are plants having a wide vertical distribution in the Lower Coal Measures.

On tracing the conglomerate, situated about 37 feet above this upper coal, Pl. CLXXXVI, Fig. 1, westward from the gap, it was found to pass along the side of the mountain about one-third of the way up the north slope. Roughly measured, it is about 610 feet from this upper conglomerate, over the second coal, or nearly 400 feet from the lower coal, to the upper massive benches of the Pottsville formation, which, for most of the way from this point to Rattling Run, form the narrow "backbone" or crest of Sharp Mountain. For the latter half of the distance from Fishing Creek to the Black Spring Gap, to which these upper ledges of the Pottsville may easily be traced, the second of the adjacent massive conglomerate plates projects vertically from the mountain crest to form an almost continuous series of highly picturesque "saw-teeth," which are often 50 feet in height and nearly as broad.

It is hardly necessary to cite the unquestionable identity of these ledges, which are also found at the top of the normal thickness of the

Pottsville in the Black Spring Gap, in order to confirm the relation of the coals in Fishing Creek Gap to the Pottsville formation, since an examination of the south slope of the mountain a half mile west of Fishing Creek Gap leaves little room to doubt that long before we reach a point in Sharp Mountain opposite the Fishing Creek Gap in the Second Mountain the entire thickness of the Pottsville formation is present in normal sequence between the Mauch Chunk and the Lower Coal Measures.

In this connection it is interesting to observe that the displacement involved in the reappearance of the Pottsville and the restoration in its normal attitude of the red shale is compensated by a marked offset of the Pocono (Vespertine) and Catskill in Second Mountain east of and at the Fishing Creek Gap in the latter. This feature is clearly brought out on the Pine Grove sheet of the Topographic Atlas of the United States.[1]

In passing it is proper to observe that the position of the "South" coal in the Fishing Creek Gap at 350 feet or more above the horizon of the Buck Mountain bed effectually precludes the existence of any considerable portion of the Pottsville formation at the south end of the section in the Lorberry Gap, provided the correlation of the lower coals in both gaps by the Pennsylvania geologists is well founded. For my own part, I am slightly disposed to consider the "South" bed at the latter gap as not very far above the base of the Lower Coal Measures.

If we hypothetically treat the South bed as a possible representative of the Skidmore coal, farther to the east along Sharp Mountain, the Lorberry Gap section may with great interest be better compared with that of the water-level tunnel at Dundas colliery No. 6, at the foot of Sharp Mountain, a few miles to the eastward, published in columnar-section sheet viii, Atlas Southern Anthracite Field, Pt. IV. If the Fishing Creek section, Pl. CLXXXVI, Fig. 1, be also compared with the Dundas section, the stratigraphic sequence in the region of the lower coals in the former will be found to be highly suggestive of that in the vicinity of the Homes and Primrose coals at Dundas.

POSITION OF THE POTTSVILLE FORMATION ALONG SHARP MOUNTAIN.

To ignorance of the stratigraphic displacement at Lorberry Gap and Fishing Creek Gap, and the consequent erroneous identification of the coals in those gaps as Lykens coals, is directly due the omission of the true Pottsville formation from the region to the west mapped as coal-bearing. For, since, in tracing these Coal Measures coals westward, they were found to lie wholly to the north of the

[1] Lorberry Gap and the gaps occupied by Fishing Creek in both Sharp and Second mountains evidently owe their existence to the structural weakness near the displacements.

crest of Sharp Mountain, it was concluded that the crest of the mountain had shifted to the lower conglomerates of the Pottsville formation. Hence it was natural that, as we shall presently see, the approximate outcrop of the Buck Mountain bed, or its equivalent, should be mapped from Black Spring Gap to Rattling Run, a distance of over 12 miles, as the "lowest Lykens Valley" bed.

SECTION AT BLACK SPRING GAP.

(STATION 19, PL. CLXXX.)

The section at Black Spring Gap has been described by both Taylor[1] and Rogers.[2] A somewhat complete representation of the coal beds above the Pottsville formation is given in section 7, columnar-section sheet viii, Atlas Southern Anthracite Field, Pt. IV. A cross section is given on cross-section sheet xxi, Pt. VI of the Atlas. Reference to these publications reveals the fact that the sections begin with the top bed of Pottsville conglomerates and extend upward in the Coal Measures. This, as was just remarked, is the natural result of the identification of the lower coals in the Lower Coal Measures with the Lykens coals. The section which I give in Pl. CLXXXVI, Fig. 2, is an imperfect one, since only a portion of the thickness of the massive conglomerates of the Pottsville is visible. It will be observed, however, that the upper bed of the red shale, which is fixed with a fair degree of precision in the section, is approximately 1,150 feet below the horizon of the coal I suppose to represent the Buck Mountain (Twin) bed. It will be noted, also, that the composition of the formation in the Dauphin Basin is essentially the same as that along Sharp Mountain, in the region of Pottsville. Especially noticeable is the great group of conglomerates which occur at the top of the formation, and which form the crest of Sharp Mountain from Fishing Creek nearly to the Big Flats. No evidence of serious search for the Lykens coals appears in this region within the limits of the Pottsville formation.

SECTION AT GOLD MINE GAP.

(STATION 20, PL. CLXXX.)

The topography of Sharp Mountain in this district and the locations of the drifts at Gold Mine Gap are shown in mine sheet xxii, Atlas Southern Anthracite Field, Pt. IV. The topography may be seen on the Lykens sheet of the Topographic Atlas of the United States. Descriptions of the coals north of the crest of the mountain are given by Taylor,[3] Rogers,[4] and Smith,[5] the former of whom published a

[1] Report on the Stony Creek Estate, Pt. II, p. 16, pl. 147, fig. 6.

[2] Geol. Pennsylvania, Vol. II, Pt. I, p. 195, fig. 181. See also Taylor's Report on the Swatara Mining District, 1839, p. 18.

[3] Report on the Stony Creek Estate, Pt. II, p. 19, pl. 147, fig. 5.

[4] Geol. Pennsylvania, Vol. II, Pt. I, p. 195.

[5] Summary Final Report, Vol. III, Pt. I, p. 2144. Descriptive notes are also contained in the early Report on the Swatara Mine District, 1839, p. 18.

cross section. A more complete columnar section of the Productive Coal Measures is presented on columnar-section sheet viii, Pt. IV of the Anthracite Atlas. In Pl. CLXXXVI, Fig. 3, I give an imperfect section, which is extended in Pl. CLXXXVII, Fig. 1, to include the Pottsville formation. In this, as well as in the gaps on either side of Gold Mine, the immense amount of coarse conglomerate blocks, largely furnished by the upper plexus of conglomerates which form the sharp crest of the mountain, usually conceals everything but portions of the most enduring ledges. It is, therefore, only by some effort that outcrops of more than the most prominent beds are to be found. For the same reason I have not attempted to definitely show the upper boundary of the red shales, which I am convinced can hardly be less than 1,130 feet below the horizon of the Buck Mountain (Twin) coal.

It is interesting to note a certain degree of regularity in the group of conglomerates at the top of the Pottsville. This appears on a comparison of the Gold Mine Gap section with the sections at Rausch Gap (Pl. CLXXXVII, Fig. 2) and Black Spring Gap (Pl. CLXXXVI, Fig. 2), to both of which these outcropping backbone ledges may easily be traced. A similar development exists at the Rausch Gap in Schuylkill County (Station 4, Pl. CLXXX), in which the Buck Mountain coal is similarly disposed.

From the mine dump, consisting of material from probably more than one of the coals drifted on the east side of the gap, were obtained the following species, which evidently represent a characteristically Productive Coal Measures flora:

Pecopteris unita Brongn.
Pecopteris arguta Sternb.?
Pecopteris arborescens (Schloth.) Brongn.
Pecopteris squamosa Lx.
Pecopteris oreopteridia (Schloth.) Sternb.
Pecopteris cf. elliptica Bunb.?
Pecopteris polymorpha Brongn.
Alethopteris pennsylvanica Lx.?
Callipteridium Grandini (Brongn.) Lx.?
Neuropteris ovata Hoffm.
Neuropteris vermicularis Lx.
Neuropteris fimbriata Lx.
Neuropteris Clarksoni Lx.
Neuropteris Scheuchzeri Hoffm.
Neuropteris Rogersi Lx.
Lepidophyllum majus Brongn.?
Cordaites sp.

The following species were also collected on the west side in the gap:

Pecopteris polymorpha Brongn.
Pecopteris cf. Newberryi F. and W.
Neuropteris ovata Hoffm.
Neuropteris Scheuchzeri Hoffm.
Annularia sphenophylloides (Zenk.) Gutb.
Sphenophyllum cf. filiculme Lx.

SECTION AT RAUSCH GAP, LEBANON COUNTY.

(STATION 21, PL. CLXXX.)

The Lower Coal Measures and the upper beds of the Pottsville formation at Rausch Gap, 3¼ miles west of Gold Mine Gap, have been the

subject of fragmentary descriptions by Taylor,[1] Rogers,[2] and Smith.[3] The cross section given by the first-named author is repeated in more complete form by Rogers and the second geological survey, though in the publications of the latter the boundary of the red shale appears to have been drawn where it might theoretically lie if the Buck Mountain (Twin) coal were the lowest Lykens coal. The position and extent of the drifting in the vicinity of this gap are shown in mine sheet xxiii.

From the section which I give in Pl. CLXXXVII, Fig. 2, it appears that the Pitch bed, the next coal below Bill's bed, probably lies within the group of conglomeratic plates at the top of the Pottsville formation. The roof shales of the coal, which I interpret as the probable representative of the Buck Mountain coal, furnish the following species:

Mariopteris muricata (Schloth.) Zeill. var. nervosa (Brongn.) Kidst.	Neuropteris Desorii Lx.
Mariopteris occidentalis D. W.	Neuropteris ovata Hoffm.
Pecopteris unita Brongn.	Neuropteris vermicularis Lx.
Pecopteris pusilla Lx.?	Neuropteris fimbriata Lx.
Alethopteris aquilina (Schloth.) Goepp.	Neuropteris Scheuchzeri Hoffm.
	Linopteris obliqua (Bunb.) Pot.

The composition of this flora indicates a horizon in the basal portion of the Lower Coal Measures, or in the Allegheny series. A drift in the same horizon on the west side of the gap yields large numbers of *Alethopteris Serlii* (Brongn.) Goepp., *Neuropteris Scheuchzeri* Hoffm., and *Asterophyllites equisetiformis* (Schloth.) Brongn.

Below the Pitch bed there is but little, if any, evidence of search for coals in the Pottsville formation at Rausch Gap. Here, as well as in Gold Mine and Black Spring gaps, effort was made to find the coals of the Lorberry and Fishing Creek gap sections, which were seen to pass, in the Dauphin Basin, to the north of the crest of Sharp Mountain instead of to the south of the latter. In his discussion of the region under consideration, Dr. Taylor,[4] whose reports and notes form the basis of the later publications relating to the district, remarks that "no examination for veins [coals] south of the backbone ledge of Sharp Mountain has taken place hereabouts." Owing to the exceptionally favorable conditions at the southeast corner of the gap, the top of the red shale was located by me, with a probably high degree of certainty, at about 1,175 feet below Bill's coal, which I have assumed to be near the horizon of the Buck Mountain bed. The boundary can be hardly more than 75 feet higher.

YELLOW SPRINGS GAP.

(STATION 23, PL. CLXXX.)

At Yellow Springs, 4½ miles west of Rausch Gap, there is a high gap in the mountain, through which a small stream, draining a section about

[1] Report on the Stony Creek Estate, Pt. II, p. 19, pl. 147, fig. 4.
[2] Geol. Pennsylvania, Vol. II, Pt. I, p. 195, fig. 182.
[3] Summary Final Report, Vol. III, Pt. I, p. 2144.
[4] Op. cit., p. 20.

2 miles in length of the Coal Measures valley, finds an escape. The topography of the vicinity is shown on the Hummelstown sheet of the Topographic Atlas of the United States and mine sheet xxiv of the Southern Anthracite Atlas, the latter of which locates the points of exploitation. Descriptions of the coals are given by Taylor,[1] and quoted by Rogers[2] and Smith.[3] Cross sections of the basin at this point are given by Taylor, and by the geological survey of the State in cross-section sheet xxi, Pt. VI of the Anthracite Atlas. All the information in the later reports relating to Sharp Mountain appears to have been derived from Taylor's report, printed in 1840.

At this gap the Pottsville appears to present its ordinary characters and its full thickness. The conditions for the discovery of the upper boundary of the Mauch Chunk shale are not favorable, but it is quite certain that the red shale is not present at 960 feet below the supposed horizon of the Buck Mountain coal. No prospecting appears to have been done in the Pottsville formation at this gap since the publication of the report by Taylor, who states that none of the coals on the south slope of Sharp Mountain had been opened or sought. However, in some early explorations, carried on in 1824, a tunnel driven through the upper portion of the Pottsville formation in the gap penetrated a bed of good coal, which, Dr. Taylor adds, was "not fully proven." The rock dump taken from a shaft which appears to have been located on this bed contains the following species:

Eremopteris decipiens.
Mariopteris tennesseeana var. hirsuta.
Sphenopteris palmatiloba var. squarrosa.
Megalopteris plumosa.
Neriopteris lanceolata.
Neuropteris tennesseeana.
Calamostachys Knowltoniana.
Bothrodendron arborescens.
Cordaites Robbii.
Cardiocarpon biscupidatum var. ohioense.
Cardiocarpon Wilcoxi.

This flora will at once be recognized as clearly referable to the Sewanee zone; and it can hardly be lower than Lykens coal No. 3. The variety of *Sphenopteris palmatiloba*, the variety of *Cardiocarpon bicuspidatum*, and *Bothrodendron arborescens* appear to bind the flora somewhat closely to that of the horizon of Lykens No. 1. Through *Eremopteris decipiens* and *Cardiocarpon Wilcoxi* the flora seems to be related to that of the Sharon coal of northwestern Pennsylvania, and it is worthy of mention that *Neriopteris lanceolata*, found at Yellow Springs, has hitherto been known only from the sandy shales at some distance above the Sharon coal, in northwestern Ohio. On the whole, I am slightly disposed to regard the horizon of the plants at Yellow Springs as higher than that of the Lykens coal No. 2.

The stratigraphic distance of this horizon below that of the Buck

[1] Reports on the Stony Creek Estate, Pt. I, p. 52.
[2] Geol. Pennsylvania, Vol. II, Pt. I, p. 196, fig. 183.
[3] Summary Final Report, Vol. III, Pt. I, p. 2145.

Mountain coal is about 210 feet; and as the latter is probably recognizable in this gap, this points toward the level of Lykens coal No. 1.

The plants from the Backbone bed, which appears to correspond to the Buck Mountain coal at Yellow Springs Gap, constitute a flora agreeing well with that listed from what I believe to be the same horizon at Rausch Gap. They are:

Sphenopteris sp.
Pecopteris villosa Brongn.?
Neuropteris ovata Hoffm.
Neuropteris plicata [Lx.].
Neuropteris capitata Lx.
Neuropteris fimbriata Lx.
Neuropteris Scheuchzeri Hoffm.
Linopteris cf. squarrosa (Ett.).
Sphenophyllum emarginatum Brongn.
Rhabdocarpos tenax Lx.?

Before passing farther toward the apex of the field, certain suggestions, resulting from a comparison of the columnar sections at Yellow Springs and the gaps to the eastward, deserve some attention, although it is not within the province of this paper to attempt the correlation of the coals of the Lower Coal Measures.

Referring to the section at Rausch Gap (Pl. CLXXXVII, Fig. 2), we may observe that Bill's bed, the "3-foot" bed, the "2-foot" bed, and probably "Dan's" bed, have been drifted in the Yellow Springs Gap, in which the intervals separating the coals are nearly the same as in Rausch Gap. A higher coal opened at Yellow Springs is probably equivalent to that designated the "Heister" in Rausch Gap, though it may possibly be the representative of the coal next below. We may safely conclude, therefore, on a comparison of these two sections, that the coal in the Pottsville formation from which the Lykens plants enumerated above were obtained lies approximately 210 feet below Bill's bed in Rausch Gap, 4½ miles to the eastward.

The section of the Lower Coal Measures at Gold Mine Gap exhibits, when compared with that at Rausch Gap, considerable variation. If the supposition that the coal which I have designated in the section (Pl. CLXXXVI, Fig. 3) the Buck Mountain (Twin) bed may be the equivalent of the Bill's bed at Rausch Gap is correct, then the bed known as "4-foot" bed in the Gold Mine Gap section would appear to be equivalent to one or both benches of "Dan's bed" at Rausch Gap; in which case the "Peacock" and the coal next above may be parallelized with coal "No. 1" and the "Heister" bed, respectively, in the Rausch Gap section, while the two coals next higher at Gold Mine may be considered as representatives of the "Gray" bed and "No. 2" bed at Rausch Gap. The "No. 4" bed in Rausch Gap lies at the approximate level, stratigraphically, of the "3-foot" bed in Gold Mine Gap. It is obvious that, if these tentative correlations, especially as they relate to the "No. 1(?)," the "Heister," the "Gray," and the "No. 2" beds at Rausch Gap, are not erroneous, the "Heister" bed, which, as designated in the published sections, is about 120 feet above the "3-foot" bed at Gold Mine Gap, can not possibly be the equivalent of the bed bearing the same name in the Rausch Gap section, less than 3½ miles distant.

In the former section the supposed Heister bed is nearly 870 feet above the horizon of Bill's bed, while in the latter section it is only about 420 feet, less than half as far.

Similarly, the section at the Black Spring Gap, often cited as Mount Eagle Gap, when compared with that in either Gold Mine Gap or Rausch Creek Gap, presents a series of intervals and coals which suggest several tentative correlations. Thus the horizon which I have designated in Pl. CLXXXVI, Fig. 2, as the place of the Buck Mountain (Twin) coal is probably on the same stratigraphic level as Bill's bed in Rausch Gap, or the lower coal at Gold Mine Gap. Likewise the horizon higher in Black Spring Gap, described by Taylor as "traces of a southern coal," would seem to correspond directly to the first coal above the Buck Mountain in Gold Mine Gap, while the "4-foot" beds in both gaps will, in that case, be on the same stratigraphic level; but if, as would seem naturally to follow, the "Peacock" coals in both sections are in reality equivalent, then we must conclude not only that the Pitch bed is not developed in the Gold Mine Gap, but also that the representative of the next coal above the "Peacock" bed at Gold Mine is identical, if exposed at all at Black Spring Gap, with the Black Spring coal. The Mount Eagle coal, the next higher in the latter gap, and the second coal opened above the "Peacock" coal in Gold Mine Gap, both of which are coincidently situated at the same distance from the Twin coal, probably represent the same bed. But, in order to illustrate the ease with which sections containing a number of well-distributed coals may be in different ways adjusted to one another, while at the same time pointing out certain other probable coincident similarities between the Black Spring section and that at Rausch Gap, let us assume that the horizon designated as "traces of a southern coal" in the former gap represents the Bill's bed in the latter. In that case, we shall find not only that the "4-foot" coal lies at essentially the same distance above the second coal in Gold Mine, but also that the "Peacock" coal is near the level of the "4-foot" bed at Gold Mine and the "Dan's bed" at Rausch Gap, in which case the Pitch coal at Black Spring Gap might, without too great a strain of the imagination, be correlated with the "2-foot" coal at Rausch Gap, and the "4-foot" coal at Black Spring might correspond to the "3-foot" coal at Rausch Gap. Continuing the same assumption as to the identity of the horizon of Bill's bed or the Buck Mountain coal at Mount Eagle Gap, it is evident at a glance that the Black Spring and Mount Eagle coals near the top of the section at Black Spring correspond, so far as stratigraphic intervals are concerned, almost exactly with the "No. 1" and the "Heister" coals, respectively, in the Rausch Gap section. The quoted names of coals represent the local identifications or correlations by the State geologists.

So far as the problems discussed in this report are concerned, the

chief interest in the correlation of the coals of the Lower Coal Measures relates to the equivalence, in the western sections, of the coals mined in the Fishing Creek and Lorberry gaps. My own observations of the terranes in the Fishing Creek Gap (Pl. CLXXXVI, Fig. 1), combined with measurements across Sharp Mountain, less than a mile west of the creek, where the Pottsville formation is present in its normal constitution and thickness, lead me to the opinion that the horizons of the two lower coals mined in Fishing Creek Gap are comparable to those of the "Peacock" coal in the Black Spring and Gold Mine sections and the coal marked as "Heister" in the Rausch Gap section. In this case the upper coal at Fishing Creek may represent the "Gray bed" at Rausch Creek Gap, the second coal above the supposed "Peacock" in Gold Mine Gap, and probably the Black Spring coal at Black Spring Gap, the lowest coal at Fishing Creek being possibly comparable to the Pitch bed at Black Spring.

The coals in the section at Lorberry Gap, Pl. CLXXXV, Fig. 3, will appear to correspond most satisfactorily, with respect to the separating intervals, to the coals of the gaps to the westward, if we assume that the lowest bed (South coal) opened at Lorberry occupies the horizon of the supposed Buck Mountain, Backbone, and Bill's beds in the other gaps. If this hypothesis is correct, the bed designated "Peacock" coal in Lorberry, Black Spring, and Gold Mine gaps, which, in the first two sections, is approximately the same distance from the Buck Mountain bed, and which is scarcely farther in the Gold Mine Gap, may perhaps safely be considered as one coal. Next, the "Zimmerman" coal in Lorberry Gap would appear to deserve comparison with the Mount Eagle bed at Black Spring, with the second exposed coal above the "Peacock" bed in Gold Mine Gap, and with either the "Gray" bed or "No. 2" bed, next higher, in Rausch Gap.

On assuming that the South coal at Lorberry is at the horizon of the Buck Mountain (Twin) bed, it becomes probable that the developed coals above the "Zimmerman" bed are higher than those represented in the Rausch Gap section, unless the "No. 4" bed in the latter section, whose distance above the Buck Mountain bed is a little greater than the corresponding interval below the next coal[1] above the "Zimmerman" in the Lorberry Gap, is the representative of the latter unnamed coal. The next higher coals in the Lorberry section will then deserve comparison with the "Heister" and "Gray" beds in the Gold Mine Gap section. The Umbehauer and the Furnace beds at the north end of Lorberry Gap probably represent higher horizons than have been developed to the westward, and it is possible that they may not even be present in the basin at and to the westward of Rausch Gap.

It will be observed that in respect to the relative intervals between

[1] This appears to be identical with the bed named Peacock coal in cross-section sheet xvi, Pt. VI of the Atlas of the Southern Anthracite Field.

the coals in the sections, the Gold Mine section appears to present the highest degree of agreement with or similarity to the Lorberry Gap section; but, whether the comparison be with the Gold Mine Gap or the Mount Eagle Gap, or the Dundas No. 6 colliery tunnel,[1] a few miles to the east of Lorberry Gap, we must conclude that if the South coal represents the Buck Mountain bed the Lorberry Gap should, in addition, contain a number of the intermediate coals which have been opened in the Black Spring and Rausch gaps. With no other evidence than the measurements of the intervals between the discovered coals on which to base correlations of the latter, an almost equally satisfactory parallelization of the beds might be framed were we to assume that the "Peacock" coal in the Lorberry Gap corresponds with the first coal above the Buck Mountain bed in the longer sections to the westward. Such an assumption is, however, manifestly untenable, since it involves the reference of the South coal, whose fossils are fully as young as, if not younger than, those of the Buck Mountain bed, to the approximate horizon of the Lykens coal in the Yellow Springs Gap, the fossils from which are referable to the Sewanee zone of the Upper Lykens division of the Pottsville formation.

I would have little reliance placed in the foregoing suggestions as to the equivalence of the various coals of the Productive Coal Measures along Sharp Mountain. It needs but an examination of the columnar sections, showing the surprisingly great variation of the intervals between the coals as actually ascertained by direct connections between the mines in the Southern field,[2] to convince one that correlation of these beds by no other means than the comparison of columnar sections is, in the Southern Anthracite field, hardly less than jugglery.

RATTLING RUN GAP.

(STATION 24, PL. CLXXX.)

Rattling Run, the most westerly gap in Sharp Mountain, is 15½ miles from Fishing Creek Gap and about 4 miles east of the point at which the Pottsville formation begins to spoon out, above Water-tank Station. The description of this gap, which is about 3 miles west of Yellow Springs, is given with considerable detail in Dr. Taylor's report,[3] which is quoted in the later State reports.[4] The principal drifts in the Lower Coal Measures are platted on mine sheet

[1] Section 6, columnar-section sheet viii, Atlas Southern Anthracite Field, Pt. IV.

[2] The variability of the Coal Measures intervals, even between near localities, is well illustrated in the diagram prepared by Ashburner, and published on columnar-section sheet iii, Pt. I of the Atlas of the Southern Anthracite Field. It is also shown in columnar-section sheet vi, Pt. II of the Atlas. Good examples of this are found at the Wood's colliery, and at Dundas colliery, No. 6 tunnels, cited above, the sections of which are not more than 3 miles distant from each other.

[3] Report on Stony Creek Estate, pp. 11 and 50, pl. 147, fig. 2.

[4] Rogers, Geol. Pennsylvania, Vol. II, Pt. I, p. 197, Smith, Summary Final Report, Vol. III, Pt. I, p. 2145.

xxv of the Anthracite Atlas. That portion of the Dauphin Basin west of Yellow Springs was somewhat thoroughly explored by the owners, the Dauphin and Susquehanna Coal Company, under the direction of Dr. Taylor. It is to this fact that most of our knowledge of the coals in this region is due.

The entire thickness of the Pottsville formation, from the bed which I assume to represent the Twin (Buck Mountain) coal to the topmost beds of the red shale is given by Taylor as 1,100 feet. Within that interval twelve coals were found. Two thin coals are reported within 170 feet of the red shale. The sixth coal from the red shale, the Reliance bed, not over 3 feet in thickness, was drifted for 461 feet. Although a very "dry coal," it was not found to be at that time profitably workable. The distance, 410 feet, from this bed to the red shale suggests the position of Lykens coal No. 4. Twenty feet to the south of the Reliance bed another coal was opened, and still another bed was discovered 40 feet to the north. A coal at the supposed horizon of the Buck Mountain bed has been opened on both sides of the gap, it having been drifted for a considerable distance on the east side. No fossil plants were obtained at this gap.

BIG FLATS.

(STATION 26, PL. CLXXX.)

As Sharp and Stony mountains, which form the two walls of the Dauphin Basin, converge toward the west, the interior valley becomes less marked, until at a point nearly opposite Watertank Station, about 9 miles from Dauphin, the Coal Measures completely fill the interval from rim to rim and form a low, slightly convex knob, the Big Flats, about 1 mile in length, the north and south faces being composed of the Pottsville formation. The topography is shown on the Harrisburg sheet of the Topographic Atlas of the United States, as well as on mine sheets xxv and xxvi, Pt. III of the Anthracite Atlas. The shaftings on the Big Flats, dating from the early part of the century, are described by Taylor, whose cross section was reproduced by Rogers.[1] Dr. Taylor reports the presence of three coals within an interval of 48 feet, from one of which several hundred tons of coal were hauled to the Susquehanna River at Dauphin prior to 1840. The three principal shafts, but a few yards apart, are platted on mine sheet xxvi. The shale from the shafts is now nearly disintegrated; yet fragments taken from the dump reveal the presence of *Neuropteris orata* Hoffm., *N. Scheuchzeri* Hoffm., *Pecopteris villosa* Brongn. ?, *Annularia stellata* (Schloth.) Wood, and *Sphenophyllum emarginatum* Brongn., species characteristic of the Lower Coal Measures.

Although we have no measurements showing the thickness of the

[1] Geol. Pennsylvania, Vol. II, Pt. I, p. 198, fig. 184.

Pottsville formation west of Rattling Gun Gap, my observations show that the upper group of conglomerate plates which have been traced the entire distance from Fishing Creek Gap may be followed, by the exercise of proper caution, when the trees are bare, for at least 2 miles west of Rattling Run Gap. Westward from this point the amount of the error of the omission of the entire Lykens group of coals on the State maps diminishes gradually. Yet in view of the lessening of the dips from 73° to 17°[1] opposite the Big Flats shaftings, it is obvious that the supposed boundary of the lowest Lykens coal, which is represented at a distance of not over 800 feet from the shafts, is too far north to include more than the upper 200 or 300 feet of the Pottsville formation, even if we suppose the coal mined in the shafts to be the Buck Mountain bed, than which, as is shown by the plants, it can hardly be lower. Were the strata nearly vertical, it is probable that Lykens coals Nos. 2 and 3 would lie outside of the approximate boundary of the lowest Lykens bed as the latter is mapped in the mine sheet. That coals are present in both of the Lykens groups in this region is evident from the shaftings along Stony Mountain and Short Mountain, which will next be considered.

SHORT MOUNTAIN SHAFTINGS WEST OF BIG FLATS.

The disappearance of the Lower Coal Measures and the commencement of the spooning out of the upper beds of the Pottsville formation occur not far west of the Big Flats and the head of Watertank Run. It is certain that, unless the folding is much closer than the apparent dips indicate and the axis is not far to the north side of the crest, the Pottsville alone remains at the Fort Lookout shafting, less than 1½ miles west of Big Flats. It should be remarked at this point that, with the exception of the Bayard shaftings on the north side of Short Mountain, no prospecting or exploitation of coal appears to have been made in this region since the earlier half of the present century. In the following brief notes reference will be for the most part confined to those old developments from which fossil plants have been obtained. The descriptive matter is derived from Taylor's report, the source of most of the information republished in the State reports.

A. The first of the developments west of the Big Flats are the Fort Lookout shaftings (Station 27, Pl. CLXXX), opened in 1838. The location of this operation is shown in mine sheet xxvi, Pt. III of the Anthracite Atlas, and a cross section of the basin at this point is contained on cross-section sheet xxi, Pt. VI of the same publication. The two shafts at this point are said to have reached a depth of 82½ feet. The coal was found too poor for mining. On searching the dump at the mouth of the shafts, a number of fossil plants were obtained,

[1] See mine sheet No. xxvi.

which, as will at once be discovered in glancing at the list, are distinctly of Pottsville age:

Mariopteris tennessecana.
Neuropteris gigantea.
Neuropteris acutimontana.
Neuropteris sp. indet.
Asterophyllites arkansanus.
Annularia acicularis.
Whittleseya elegans var. minor.

Furthermore, nearly all of the species will be recognized as having a distribution in the Upper Lykens division. It is certain that this flora can not be below the horizon of Lykens coal No. 3, when *Neuropteris gigantea*, *Asterophyllites arkansanus*, and the peculiar form of *Mariopteris tennessecana* strongly suggest a more intimate relation with the flora of Lykens coal No. 2. It is probable that the level of this flora is not lower than Lykens coal No. 2 or higher than Lykens coal No. 1.

B. Of the economic results obtained by the Bayard shaftings (Station 28, Pl. CLXXX) we have no other information than that given by mine sheet xxvi, which shows the location of four shafts, and by the fossils obtained from the rock dumps. From the lower of the shafts there were obtained an indeterminate species of *Mariopteris*, *Neuropteris Pocahontas* var. *inaequalis*, and a species of *Sporocystis*. From a higher shaft, not over 85 feet from the latter, the following-named species were obtained in shale mingled with waste coal:

Mariopteris pottsvillea.
Neuropteris Pocahontas var. inaequalis.
Lepidophyllum quinnimontanum.
Rhabdocarpos acuminatus.

A comparison of these florulas, both of which are distinctly referable to the Lower Lykens division, shows that while the plants from the lower drift contain no types indicative of a particular horizon, the species from the upper drift include, in *Mariopteris pottsvillea*, *Neuropteris Pocahontas* var. *inaequalis*, and *Lepidophyllum quinnimontanum*, three species characteristic of the *Mariopteris pottsvillea* zone, or the approximate horizon of Lykens coal No. 4. The association and facies of the individual plants from this drift are clearly suggestive of the level of the Kemble drift on Broad Mountain, which, as we have already seen, is most probably near the horizon of Lykens coal No. 4. If this correlation is valid, then it becomes probable that the horizon of the lower drift is near the level of Lykens coal No. 5.

C. The next locality at which fossil plants were obtained is a pit just above the "north vein drift" (Station 29, Pl. CLXXX), close to the divide in the saddle of the mountain, nearly due north of White Springs Station. The drift at this point was opened in 1827 for the distance of 100 feet on a dip 30° S. As might be expected, nearly all of the excavated material is now entirely disintegrated. Such plant fragments as were obtained plainly show the presence of a number of species which, though not clearly indicative of the approximate hori-

zon of Lykens coal No. 4, are nevertheless strongly suggestive of that level. They are certainly from the Lower Lykens division.

Mariopteris pottsvillea.
Mariopteris sp. indet.
Neuropteris Pocahontas var. inæqualis.
Whittleseya Campbelli.

The geographic position of this drift is shown in mine sheet xxvi, Pt. III of the Anthracite Atlas; and a cross section of the mountain is included in cross-section sheet xxi, Pt. VI of the Atlas.[1]

D. On the south side of the crest of Short Mountain, but a short distance to the west of the "north vein drift," is located Kugler's drift (Station 30, Pl. CLXXX), opened in 1824. The positions of both Kugler's drift and Young's drift, the latter being a little to the west, are shown on mine sheet xxvi. In his report on the Stony Creek coal area, Dr. Taylor reports the presence of a good coal in the former, reaching a maximum thickness of 4 feet, its horizon being 25 feet below that of the coal at Young's drift, while a smaller bed, the "little vein," is said to have been discovered 20 feet lower than Kugler's. Although the shales from Kugler's drift are far decayed, they still reveal the presence of—

Mariopteris eremopteroides.
Neuropteris Pocahontas var. pentias.
Cordaites Robbii.

Although these species are insufficient in themselves to form the basis of an attempt at a precise correlation, their entire agreement with the flora of the region of Lykens coals Nos. 5 and 6, for which I have tentatively suggested the term *Mariopteris eremopteroides* zone, will at once be recalled. Such a tentative reference carries more weight than mere suggestion, when the stratigraphic intervals of the neighboring coals are taken into account. It seems, indeed, far from improbable that, if the measurements reported from these coal drifts are to be relied upon, the 51-inch coal in Young's drift, which is 25 feet above Kugler's, may represent Lykens coal No. 5, the Kugler's drift being in Lykens coal No. 6, while the "little vein," 20 feet below, might represent the "zero" coal of the Wiconisco Basin. It appears that in this region of Short Mountain three coals of the Lower Lykens division are present, two of which may attain a workable thickness, although the attitude of the beds near the axis of the syncline probably unfits them for profitable exploitation.

E. A small collection of fossil plants was obtained from the most westerly of the shafts shown on the immediate crest of the mountain on mine sheet xxvi of the Anthracite Atlas (Station 31, Pl. CLXXX). It contains the following species:

Mariopteris eremopteroides?
Neuropteris Pocahontas var. pentias.
Lepidophyllum quinnimontanum?
Whittleseya Campbelli.
Trigonocarpum ampullæforme.
Trigonocarpum Helenæ.

[1] Reproduced in Summary Final Report, Vol. III, Pt. I, pl. 394.

The composition of this flora conclusively proves its presence in the Lower Lykens division. The first three species mentioned are to a certain extent characteristic of the lower zone of that division and might be expected in the vicinity of Lykens coals Nos. 5 and 6. Against so low a reference as coal No. 6, however, is opposed the presence of *Lepidophyllum quinnimontanum* and *Trigonocarpum Helenæ*, which, though not unknown in the horizon of No. 5, are in general more characteristic of Lykens coal No. 4, and which have not yet been found so low as coal No. 6. It does not, therefore, appear permissible to refer this flora to a lower level than that of Lykens coal No. 5, on the one hand, while, on the other hand, there is no evidence of weight to lead us to regard it as high as Lykens No. 4. Accordingly, as between the three horizons, this flora should perhaps tentatively be referred to that of Lykens coal No. 5. Concerning the depth of the shaft or the thickness of the coal touched at this point I find no printed information.

F. The only other locality on Short Mountain from which fossils have been collected is a drift which, as shown on mine sheet xxvii of the Anthracite Atlas, is located near the extremity of the mountain, in the apex of the basin, and within 2,800 feet of the outcrop of red shale beneath the last of the conglomerates in the axis of the spoon of the Pottsville formation. This seems to be one of the shaftings opened in 1802. Naturally the shales are for the most part completely disintegrated, and no encouragement is offered for the collection of fossils. Some fragments of bone, however, still show traces of Calamarian stems and cortices of various types, as well as rather abundant fruits of *Trigonocarpum ampullæforme*.

THE LYKENS COALS IN STONY MOUNTAIN.

Intelligent and thorough search for the Lykens coals seems to have been made at but two points between Big Flats and the Kalmia colliery, a distance of 16 miles. At the more western locality, on the Dull and Hoff lands (Station 25, Pl. CLXXX), but about 2 miles east of the Big Flats, four or five of the Lykens coals were located and shafted in 1888. The uppermost of these coals, which would appear from the description[1] to be 400 or 500 feet below the probable approximate horizon of the Buck Mountain bed, is said to be thin. About 200 feet below this a thin, clean, bright coal was discovered. The next bed, about 150 feet lower, contains 2 feet 7 inches of good coal, reported as the best found. One hundred feet lower, 5 feet 5 inches of crushed and dirty coal was opened, while a bed of impure coal and shale was located 40 or 50 feet below the last.

From the thickness and order of the intervals (see table, p. 864), we may tentatively assume that the lowest bed represents Lykens coal

[1] Summary Final Report, Vol. III, Pt. I, p. 212.

No. 6; the thick bed, 40 or 50 feet higher, may then be the Lykens coal No. 5, and the 2-foot 7-inch bed of good coal 100 feet above the last will perhaps correspond to the place of Lykens coal No. 4, while the coal about 150 feet higher is possibly near Lykens coal No. 2 or No. 3. As corroborating to a certain degree, or as slightly indicative of the correctness of, these hypothetical correlations, the small collection of plants apparently derived from the roof of the third coal (numbering from the lowest), which we have assumed to be Lykens coal No. 4, may be enumerated:

Mariopteris pottsvillea.	Asterophyllites parvulus.
Neuropteris Pocahontas.	Trigonocarpum ampullæforme.

The first of these species seems to be characteristic of the zone of that coal, while the third is more common in the same horizon. On the whole, it appears very probable that the three principal lower Lykens coals have been opened in the prospect shafts on the Dull and Hoff lands.

At a point nearly north of Rausch Gap[1] two coals, which from surface appearances and the thickness of the intervals would seem to represent the supposed Lykens coals Nos. 4 and 5 at the locality last considered, have been opened by trial slopes (Station 22, Pl. CLXXX). The coal at the mouth of the upper of the two slopes is apparently of good quality and in good condition. No information is at hand as to the thickness of the beds in the slopes, which are now fallen shut. The lack of information is in itself indirectly indicative of no great thickness for the combustible.

At the Kalmia colliery (Station 41, Pl. CLXXX) Lykens coals Nos. 4, 5, and 6 were worked to some extent. Owing, however, both to the irregularity of the beds at this point in thickness and condition and to the more advantageous conditions for mining about the Georges Head anticline, the greater part of the "workings" were abandoned in favor of the latter area. The columnar section at this mine from the top of Lykens coal No. 5 downward into the red shale is shown on Pl. CLXXXIV in continuation with the section at the Lincoln colliery, from the connected gangways[2] of which a portion of the Kalmia territory is now directly mined.

GENERAL CONDITIONS RELATING TO THE OCCURRENCE OF THE LYKENS COALS IN THE DAUPHIN BASIN.

A review of the foregoing brief descriptive notes concerning the Pottsville formation in the Dauphin Basin shows that along the north side of the narrow trough, which is nowhere more than 2 miles in width,[3] several of the Lykens coals, one or more of which, usually in

[1] Atlas Southern Anthracite Field, Pt. III, mine sheet xxiii.

[2] Idem, Pt. III, mine sheets xxi and xxii.

[3] This refers to the distance across the basin from margin to margin; not to the length of the curve.

the Lower Lykens group, is nearly or quite of workable thickness, have been found in every district where a thorough search has been made. They are also found to extend along the base of the rising axis in Short Mountain. Furthermore, it has been shown that, owing to the presence of an unobserved fault which cuts off the whole or nearly all of the Pottsville formation at Lorberry and Fishing Creek gaps, not only were the soft, inferior Productive Coal Measures coals exploited at these gaps mistaken for degenerate developments of the Lykens coals, and consequently pronounced inferior or worthless, but on account of the trend of the former coals along the north side of Sharp Mountain the entire Pottsville group of coals has been supposed to lie to the north of the crest of the mountain. The outcrop, or supposed approximate outcrop, of the lowest Lykens coal was therefore mapped by the late anthracite survey of Pennsylvania[1] along or near a horizon not lower in most places than the horizon of the Buck Mountain coal, the conventional base of the Lower Coal Measures, from Fishing Creek Gap to a point about 2 miles west of the Rattling Run Gap, an entire distance of over 17 miles. To the same misinterpretation at Lorberry and Fishing Creek gaps is also due the fact that no systematic search has ever been made for coals south of the crest of Sharp Mountain (where no coals were supposed to occur) between Fishing Creek Gap and Rattling Run Gap.

It must not be understood from the above statement of facts that Lykens coals in good condition lie awaiting the search of the prospector along the south slope of Sharp Mountain. On the other hand, the vertical or very highly inclined attitude and the often crushed or slipped condition of the other coals along Sharp Mountain render it probable that the Lykens coals will here also be found generally inferior in structure, and perhaps in composition, as compared with the present standard requisite for profitable mining. It is the purpose of this review of the stratigraphy of the region not merely to secure greater accuracy in the mine maps of the Dauphin Basin, or to add to our knowledge of the floras of the Pottsville formation in this region, but to call attention to the facts: (1) That the soft or semibituminous coals on the north slope of Sharp Mountain between Fishing Creek and Rattling Run gaps, hitherto regarded as the Lykens coals, are really in the Productive Coal Measures; (2) that practically no search[2] has been made for coals in the Pottsville formation through-

[1] Credit is due the opinion expressed by Mr. A. DW. Smith in a footnote to the Summary Final Report of the State Survey (p. 2140), that the outcrops of the red shale and the lowest Lykens coal are drawn 800 to 1,000 feet too far north between Lorberry Gap and Rattling Run Gap, most of the coals in the Lorberry and Fishing Creek gaps being referable to the Lower Coal Measures, although he assumes the full thickness of the Pottsville formation to be present at the latter gaps. This footnote, which I had not seen until the writing of the present paper, is quite at variance with all other portions of the text relating to the Dauphin Basin in Mr. Smith's report.

[2] Exceptions of little importance are the discoveries of the Reliance coal at Rattling Run Gap and the thin coal near the top of the Pottsville formation in Rausch Gap, section 2, Pl. CLXXXVII.

out this portion of Sharp Mountain, 17 miles in length, for the reason that no coals were expected to occur there; (3) that nearly the entire formation, including both groups of the Lykens coals, lies south of the general crest of the mountain; (4) that the discovery, especially in the Lower Lykens division, of several Lykens coals, one or more of which appears to be of good quality and of workable or nearly workable thickness at every point[1] at which a moderately thorough search has been made along the opposite side of the basin and along Short Mountain, offers every assurance of the presence of some of the coals on the south side of the basin, though the steep or nearly vertical position of the beds bespeaks a poorer condition and less easy exploitation of the coals. It is, however, within the range of probability that, should the consumption of anthracite continue at nearly the present rate, the demand for the Lykens red-ash coals, which are more highly appreciated for domestic purposes, will exhaust the richer and more favorably situated and profitably mined deposits, some of which are already far toward exhaustion, and cause the exploitation of Lykens coal in regions now regarded as wholly unprofitable; in which case the Lykens coals of Sharp and Stony mountains, though so often crushed, may enter into competition with the thinner coals of the Pottsville formation in other portions of the anthracite fields.

THICKNESS OF THE FORMATION IN THE SOUTHERN ANTHRACITE FIELD.

In the discussion of the lower limits of the Pottsville formation attention was especially called (p. 831) to the great variations in the measurements of the section in the Southern Anthracite field, due to the indefiniteness of the method in use and the elements of personal opinion and preference consequently involved. As was then remarked, the method of fixing the boundary at the top of the highest bed of typical red shale or sandstone, which has been followed in the measurements hitherto given in this report, is only the application in the anthracite region of the custom in vogue in the geologic work of the bituminous basins of the State. The unsatisfactory features of this method, which have already been pointed out in the Southern Anthracite field, are appreciated in advance.[2] It is admittedly arbitrary and variable; yet in its application it not only assures an identical horizon over considerable distances, but it is definite in each exposure, and effectually disposes of the personal variations resulting from the choice of an individual horizon throughout a series representing a gradual

[1] Dull and Hoff lands north of Rattling Run Gap and drifts north of Rausch Gap, mine sheets xxv and xxiii, respectively.

[2] Concerning the variability of the horizon of the uppermost bed of red shale, Smith (Summary Final Report, Vol. III, Pt. 1, p. 1921) remarks as follows: "In the Southern field these transition beds have, in places, a thickness of 500 to 600 feet. The transition beds and the lower beds of XII also exhibit decided variations in the materials composing them. At times heavy conglomerates predominate, with but few sandstones and shales, or again the whole series may be composed of coarse sandstones and of shales, with the green and reddish tinge running high in the formation, making it difficult,

transition, 400 or 500 feet in thickness, such as is exhibited in the sections at the Pottsville Gap, Pls. CLXXXI, CLXXXII, and in the Lincoln region, Pls. CLXXXII, CLXXXIII. It is purposed in the following pages to present the results obtained by both methods.

Beginning with Mauch Chunk, at the eastern apex of the Southern field, and proceeding westward, the measurements of the Pottsville formation (XII), as given by Rogers,[1] are: Mauch Chunk, about 950 feet; Nesquehoning, 792 feet; Tamaqua, about 803 feet; Pottsville, about 1,030 feet; Lorberry Gap, about 675 feet;[2] Yellow Springs, about 660 feet;[3] Kohlers Gap, 230 feet; Bear Gap, 460 feet. The measurements of all the intervals given by A. DW. Smith are of great value, since his statements are based on the enormous amount of instrumentally accurate data accumulated by the second geological survey of the anthracite regions, all of which were passed in review by him. As stated by Mr. Smith, in the Final Summary Report, the thickness of the formation is as follows: Locust Gap, Tamaqua, 1,296 feet; Sharp Mountain Gap, Tamaqua, 1,130 feet; Broad Mountain, about 1,200 feet; Pottsville Gap, 1,350 feet; Swatara and Ransch gaps, 1,100 or 1,200 feet; Lorberry Gap, 1,500 or 1,600 feet;[4] vicinity of the Lincoln mine, 1,475 feet; Kalmia region, 1,400 to 1,500 feet; Williamstown, about 1,400 feet.

The preceding measurements begin with an arbitrary boundary, usually within or below the transition series. The following measurements start from the topmost bed of red shale and extend to the supposed horizon of the Buck Mountain coal, except along Locust Mountain, in the Panther Creek Basin, where the measurements from both the A and B beds are given, it being nevertheless understood that the A coal at Tamaqua is referable to the Lower Coal Measures.[5] The measurements opposite the names of localities marked by an asterisk (*) are compiled from the sections published by the State geological survey.

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even when a complete section is at hand, to decide where the line between the two formations should be drawn. It is not safe to always take the highest red shale bed as a limit, as beds of red shale, usually thin, but in appearance like the mass of No. XI, are not infrequently seen high up in the conglomerates of XII, and occasionally among the overlying Coal Measures; nor will it suffice to take the lowest conglomerate, as beds of conglomerate are often found well down in the red shales of XI. The fixing of a precise limit between the two formations becomes, in many instances, a matter of individual preference and judgment."

[1] Geol. Pennsylvania, Vol. II, Pt. I, pp. 146 and 147.

[2] This, as we have already seen, consists in part, if not wholly, of the beds of the Productive Coal Measures.

[3] It is difficult to account for this measurement by Rogers at Yellow Springs, except on the supposition that the dense, ferruginous surface deposits which occur in the lower end of the gap were mistaken by him as indicating the presence of the Mauch Chunk red shale.

[4] The terranes included in this measurement belong for the most part, if not exclusively, to the Productive Coal Measures.

[5] The Buck Mountain coal, or its supposed horizon, is taken as the upper limit in my measurements, both for the sake of the uniformity desired in the comparisons and because the true paleontologic base of the formation can not in many cases be fixed, because of the lack of collections of fossils from a number of horizons not far below the Buck Mountain level. The paleontologic upper limit of the Pottsville is probably within 200 feet, at most, of the conventional limit, the Buck Mountain bed, in all sections.

Nesquehoning Gap, (*) 1,150 feet, or 940 feet from the A coal; Lansford railroad tunnel, (*) 675 feet from the A coal, or 780 feet from the B coal; Sharp Mountain Gap, (*) Tamaqua, 850± feet; Locust Mountain Gap, Tamaqua, 750 feet from the A coal, or 880 feet from the B coal, according to the statement of Mr. Ashburner;[1] Pottsville Gap, 1,195 feet; Westwood Gap, 1,165 feet; Broad Mountain, in the region of Altamont colliery No. 2, (*) 1,210 feet from the horizon, which would seem to be referable to, and is, at least, probably not lower than, the Buck Mountain bed to the red shale; Swatara Gap,[2] 1,025± feet; Rausch Gap, Schuylkill County, 1,205± feet; Lincoln region, (*) 1,110 feet; Black Spring Gap, 1,160± feet; Gold Mine Gap, 1,130± feet; Rausch Gap, Lebanon County, 1,165± feet; Rattling Run, (*) 1,100 feet; Kohlers Gap, (*) 1,219 feet; Williamstown, (*) 1,460 (?) feet.

Since a number of the localities cited are either common to two or more of the preceding lists, or are so near as to leave little room for actual important variation, the measurements at these points may be combined in a table, which will show the thickness of the Pottsville formation as measured, first, by Rogers; second, by the second geological survey of Pennsylvania, an arbitrary lower limit being used; and, third, as either measured or compiled by me, the topmost bed of red shale being taken as the lower limit of the Pottsville formation.

Measurements of the Pottsville formation in the Southern Anthracite field.

Location of section.	Measured by—		
	Rogers.	Smith.	White.
Nesquehoning Gap	792	1,155	940 A (1,150 B)
Lansford railroad tunnel	.....	878	690 A (802 B)
Locust Gap, Tamaqua	803	1,296	750 A (952 B)
Sharp Mountain Gap, Tamaqua		1,130	850±
Pottsville Gap	1,030±	1,350	1,195
Westwood Gap	.....	.....	1,165
Broad Mountain, near Altamont 2	.....	1,200	1,210±
Swatara Gap	.....	1,100 to 1,200	1,025±
Rausch Gap, Schuylkill County	.....		1,205±
Lincoln-Kalmia	.....	1,475	1,110±
Black Spring Gap	.....	.....	1,160±
Gold Mine Gap	.....	.....	1,130±
Kohlers Gap	230	.....	1,219
Rausch Gap, Lebanon County	.....	.....	1,165±
Williamstown	.....	1,400±	1,460?
Rattling Run	.....	1,100	1,100

[1] Second Geol. Survey Pennsylvania, Anthracite Region, Rept. I, 1883, p. 80.

[2] Perhaps not over 950 feet.

From the above table it appears that over 300 feet of transition series has been included within the Pottsville formation in some of the measurements published by the State survey. Among the deductions to be drawn from the table, perhaps the most important are: (1) Whatever the arbitrary base line employed in the measurements, the formation is found to be thickest in the central portion of the field, i. e., the region including Pottsville and Lincoln. (2) The formation appears to be as thick at 7 or 8 miles from the present southern border of the field as in Sharp Mountain. Thus on the Broad Mountain, near Altamont colliery No. 2, the diamond drill bore hole can hardly have begun much higher than the Twin coal, while the section at Kohlers Gap in Bear Mountain, which was carefully described and measured by Rogers, appears to be as thick as all those measured by myself in Sharp Mountain. It seems not improbable that the great thickness of the formation in the Williamstown tunnel, as platted in columnar-section sheet vii, may be due to error in the identification of the Buck Mountain bed, or in the computation of the the thickness of the beds. (3) The diminution of the thickness of the Pottsville between the type section at Pottsville Gap and the Lansford railroad tunnel in Locust Mountain is well marked, as appears to be also the rapid increase which is noted in the region of Nesquehoning Gap. I am disposed to believe that in the Panther Creek Basin the B bed is perhaps nearer the level of the Twin coal, or supposed Buck Mountain bed, than is coal A, which, although distinctly referable at Tamaqua to the Lower Coal Measures, seems to carry a rather less recent flora than that of the Twin coal. Neither is it certain that the A bed at the Nesquehoning Gap is identical with that similarly designated at Tamaqua. (4) Another diminution in the thickness of the section seems to occur along Sharp Mountain from Pottsville to Swatara Gap, where the interval from the supposed Twin bed to the top of the red shale is perhaps less than 950 feet. (5) One of the most interesting facts brought to light in this comparison is the apparently but slight decrease of the formation in Sharp Mountain in passing westward along the Dauphin Basin, where at Rattling Run, near the western end of the field, it still retains a thickness of 1,100 feet. This observation is of greater weight because it is based on careful measurements apparently extending only from the uppermost bed of red shales.

The more marked variations in the thickness of the Pottsville are perhaps due to differences in the horizons taken as the upper or the lower limits, or to changes in the thickness of the several terranes from point to point, rather than to the existence of an unconformity at the base of the formation. Even at Tamaqua, where the discrepancy between the thickness of the Pottsville, as measured in the two gaps, points, perhaps, toward discordance, the difference may be due either to variation, without unconformity at the base, or to the absolute

failure of the Twin coal to appear in the Locust Gap section.[1] Allowance for reduction by pressure and crushing should also be made in some sections.

The relatively slight diminution in the thickness of the Pottsville in passing along the Dauphin Basin to Rattling Run, as conclusively shown in the table given above, renders the rapid decrease in the thickness of the formation before reaching the Broad Top Basin, about 75 miles distant, where it is said[2] to be only 160 feet thick, somewhat remarkable. In view of the geographic position of the Broad Top field on the east side of the Appalachian trough, between the very thick Virginia and the Schuylkill sections, the alternatives—unconformity, or diagonaling of the Pottsville base in time—discussed in connection with the subject of the lower limit of the formation in another part of this report are again called to mind. The surprising difference in the measurements of the sections seems not wholly satisfactorily explained by the theoretically farther offshore position of the Broad Top Mountain, although that may account for a large part of the difference. The more probable explanation, as it appears to me, is that Broad Top was not directly in the influence of the strong, fluctuating, detritus-laden currents, which may have built a large portion of the great, broad, shoal-water terrace in the Schuylkill-Swatara region, while red argillaceous shale was still being deposited in the Huntingdon County region. Unfortunately, no plants have been collected from the latter region to show the relative age of the lower beds.

The remarkable strength and the varying activity and directions of the movements of the early Pottsville sediments over the Mauch Chunk delta in the Schuylkill-Swatara region during a period of oscillating tide level are proved by the alternation and high degree of irregularity in the Pottsville beds, by the transportation of the conglomerate-building material to a long distance from the present margin—i. e., by the long radius of the fan—and by the size of the bowlders which are sometimes encountered far from the margin of the field. In illustration of the latter circumstance, the occurrence of bowlders 7 or 8 inches in diameter in Head Mountain, described by Rogers,[3] may be cited.

As illustrating the thinning of the beds to the northwest, as well as indicating the radius of the thickened formation of the Southern Anthracite field, it may be of interest to quote a number of measurements of the Pottsville in other regions, in both the anthracite and the bituminous basins. From a thickness of about 1,200 feet in the type section, or nearly the same on the Broad Mountain at the northern

[1] In this connection I should add that my measurement from the A coal to the top of the red shale agrees exactly with that published by Mr. Ashburner in section 49, in columnar-section sheet ii, Pt. I of the Atlas of the Southern Anthracite Field. Coal B, however, appears, as is described by Smith, to be at least 202 feet higher than A, instead of but 115 feet, as stated by Ashburner in his report of the Anthracite Survey for 1883, p. 80 [202 feet on p. 106].

[2] I. C. White, Bull. U. S. Geol. Survey No. 65, p. 185.

[3] Geol. Pennsylvania, Vol. II, Pt. I, p. 22.

margin of the Southern Anthracite field, the Pottsville formation decreases to about 850 feet at Shamokin Gap, toward the west end of the Western Middle Anthracite field, and to 830 feet, more or less, at the Mahanoy tunnel at the eastern end of the same field. Here the upper conglomerates often contain pebbles of the size of an egg, while the lowest beds are interlarded with red shale, as in the Southern Anthracite field. A very rapid change is to be observed in the basins of the Eastern Middle field, where the contact with the red shale becomes distinct. Thus in the Silver Brook Basin, on the southern border of that field, the formation is but 500 feet thick, while in the Upper Lehigh, on the north, it is said to be not over 200 feet in thickness. The measurements of the formation in the Northern Anthracite field vary, the average being about 225 feet. It is undoubtedly much less than this at points, such as the well-known fossil plant and insect locality at Campbells Ledge, near Pittston, where, if Dr. I. C. White is correct in the recognition of the equivalent of the Mauch Chunk formation, the Pottsville, assigned a thickness of but 54 feet by him, can hardly exceed 100 feet at most, as limited according to the standard employed in the bituminous basins.

The diminution of the formation from 1,100 feet at Rattling Run, in the Dauphin Basin, to 160 feet in the Broad Top field is perhaps less remarkable than the decrease in passing from the Southern field to Upper Lehigh, which is but 18 miles from Tamaqua and 14 miles from Nesquehoning. Both of the thinner sections may be considered as offshore stations, as compared with the thick sections farther to the southeast. It is, however, difficult to form an estimate of the relative remoteness of any of these points from the original coast of the interior Carboniferous sea.

In the Bernice Basin, Sullivan County, the Pottsville does not appear to exceed 125 feet in thickness, and a similar measurement is reported where the formation touches the New York State line. Throughout most of the bituminous basins in southern and western Pennsylvania, including the northern margin of the coal field, near the Ohio line, the formation averages about 250 feet, more or less, in thickness. Southwest of Broad Top, on the Potomac River, the section is somewhat thicker, and from that point the Pottsville shows a generally, though not invariably, increasing thickness until we reach the Kentucky–Virginia border, where it probably exceeds 2,500 feet.

VARIATION IN THE CONSTITUENT TERRANES OF THE FORMATION.

It needs but a comparison of the carefully measured, detailed columnar sections of diamond-drill bore holes and of tunnels, published in Pts. IV and IV B of the Atlas of the Southern Anthracite Field, to demonstrate not only the variability in the thickness and composition

of the Pottsville strata, but also the astonishing lack of continuity among even conspicuous and important strata. In fact, I know of no region in the Appalachian trough in which the local irregularities of the coal-bearing formations are more marked than in the Southern Anthracite field. It is not difficult to account for this irregularity on the hypothesis I accept in explanation of the conditions attending the deposition of the Schuylkill-Swatara and Virginia sections. The formation of beds of coal under such conditions seems to necessitate the assumption either that there existed, at various times on the surface of the Pottsville terrace or fan, coastal lagoons or protected basins, the sluggish water supply of which was laden for short periods with little else than vegetable matter, or, as appears more probable, that, as the result perhaps of occasional uplifts, large areas lying within bars or shoals were converted during short intervals of quiescent stability into Carboniferous swamps or lagoons in which considerable irregular deposits of plant matter accumulated before the current erosion of the barriers or the renewal of the general movement of submergence terminated the conditions favorable for coal formation and permitted the invasion of the coarsely detritus-laden waters. The interruption of the general subsidence by short periods of elevation and stability, while permitting at once the accumulation of vegetable matter in one region and the seaward extension of the submarine terrace in another during the periods of higher level, accounts also for the readiness with which the conglomeratic sediments, which usually almost directly, when not immediately, overlie every Lykens coal, were swept across the carbonaceous deposits on the recurrence of the general downward movement.

The variability in the thickness of the coals, their irregular intervals and distribution, as well as the fact that the areas containing the lower Lykens coals are so restricted, compared with the area of the anthracite fields, appear to sustain this hypothesis as explaining both the deposition of the coals and the extent of the formation.

As partially illustrating the variation of the several members of the Pottsville formation in the mining district of the Southern Anthracite field, while showing the prevailing intervals between the coals, the following incomplete table is presented, although it is extremely fragmentary and evidently insufficient to serve as the basis of any important generalizations.

Table showing intervals between the principal Lykens coals in the Lincoln-Lykens mining region.

[The intervals indicated are those between the horizons in whose columns the numbers occur.]

Locality.	Distance from coal named below to next horizon under which record is placed.	Lykens coal No. 1.	Lykens coal No. 2 or 3.	Lykens coal No. 4.	Lykens coal No. 5.	Lykens coal No. 6.	Top of red shale.	Total from Buck Mountain coal to red shale.
Pottsville Gap	Buck Mountain.	380?	170?	160?	60?	.....	425?	1,195
Broad Mountain (near Gordon plane).	do	.....	.....	480	.....	.....	.....	.....
Swatara Gap	do	.....	.....	640	.....	.....	385±	1,025±
Ransch Gap (Schuylkill County).	do	.....	.....	.....	910	65	230	1,205±
Colket	do	103	.....	.....	.....	.....	.....	.....
Lincoln	do?	250±	370	245	120	48	.....	.....
New Lincoln	do	250±	320	250	130	47	.....	.....
Good Spring	do	210	.....	.....	.....	.....	.....	.....
Kalmia	.....	.....	.....	(—)	110	75	25	.....
Kohlers Gap	Buck Mountain.	372	288	322?	87	90	60	1,219
Williamstown	do	.....	.....	980	140	75	270?	1,460?
Gratz	.....	.....	.....	.....	(—)	.....	100±	.....
Shiro tunnel	.....	.....	.....	(—)	70	66?	50?±	.....
Rattling Run	Buck Mountain.	.....	410	.....	.....	.....	690	1,100
Dull and Hoff shafts, near Big Flats.	do	500±	200?	160?	100?	45±	.....	.....

It is of interest, however, to note a few of the variations, such as that in the interval between the Buck Mountain coal and Lykens coal No. 1, which at Colket is 103 feet; at Good Spring, 4 miles west, 210 feet, while at New Lincoln, farther south, but in reality about 2½ miles from either Good Spring or Colket, it is 250 feet. Similarly, the interval between the Lykens coals 5 and 6, which is but 47 or 48 feet in the New Lincoln and Lincoln mines, measures 75 feet at Kalmia, with which direct underground connection is made, while the same thickness is observed at Williamstown.

In passing from the subject of the variability of the terranes of the Pottsville formation, it should be observed that the succeeding Coal Measures also, especially in the Panther Creek Basin and the regions west of Pottsville, show the continuation of conglomerate sedimentation in enormous quantities, though the formation is generally softer

than the Pottsville. In certain instances conglomeratic sandstones and conglomerates compose about one-third or more of the entire section. As might be expected, this feature, which is well illustrated in the sections located in the Tremont region[1] and in the Panther Creek Basin, is not less striking than the astonishing variability in the thickness of the intervals separating the coals of the Productive Coal Measures in the same regions. In this connection it is both interesting and instructive to make a comparison of the columnar sections published in columnar-section sheets x of Pt. IV, vi of Pt. II, and iii of Pt. I, of the Atlas of the Southern Anthracite Field.

NOTES ON OR DESCRIPTIONS OF SOME OF THE MORE CHARACTERISTIC SPECIES OF FOSSIL PLANTS OF THE POTTSVILLE FORMATION IN THE SOUTHERN ANTHRACITE FIELD.

It was my original purpose to have the description of the stratigraphy of the Pottsville formation in the Southern Anthracite field accompanied by full descriptions and illustrations of the fossil plants, which, with the exception of *Spirorbis*, rare crustacean fragments, or still rarer cockroach wings, appear to constitute the sole organic remains yet brought to light. When, however, it was found not only that the manuscript and plates were too voluminous for the present form of publication, but also that the subsequent preparation of a complete report covering the fossil plants of the formation in other portions of the Appalachian province would include the republication of many of the descriptions of the fossils from the Southern Anthracite field, it was determined to confine this report to the description, limitation, and definition of the Pottsville formation as found in the type section and region, and such economic or general geologic results as had been reached in the course of the paleontologic and stratigraphic studies in the field, as well as such general or broad correlations as might be proper in a preliminary paleontologic publication.

The following pages are devoted to descriptions of some of the more important stratigraphic species of the several zones of the Pottsville formation or to notes, either relating to species already known elsewhere or concerning forms closely allied to well-known types. Following is a list of the entire flora.

[1] See columnar-section sheet x, Atlas Southern Anthracite Field, Pt. IV B; and columnar-section sheets i and ii, respectively, of Pt. I of the Atlas.

LIST OF FOSSIL PLANTS FROM THE POTTSVILLE FORMATION IN THE SOUTHERN ANTHRACITE FIELD.

Aneimites pottsvillensis D. W.
Aneimites sp.
Eremopteris subelegans D. W.
Eremopteris sp. No. 1.
Eremopteris sp. No. 2.
Eremopteris dissecta Lx.?
Eremopteris lincolniana D. W.
Eremopteris Cheathami Lx.
Eremopteris decipiens (Lx.).
Eremopteris Aldrichi D. W.
Mariopteris eremopteroides D. W.
Mariopteris pottsvillea D. W.
Mariopteris Phillipsi D. W.
Mariopteris Phillipsi var. intermedia D. W.
Mariopteris pygmaea D. W.
Mariopteris nervosa (Brongn.) Zeill. var. lincolniana D. W.
Mariopteris tennesseeana D. W.
Mariopteris tennesseeana var. hirsuta D. W.
Mariopteris cf. acuta (Brongn.) Zeill.
Mariopteris sp.
Pseudopecopteris obtusiloba (Sternb.) Lx. var. mariopteroides D. W.
Pseudopecopteris cf. squamosa Lx.
Sphenopteris umbratilis D. W.
Sphenopteris Lehmanni D. W.
Sphenopteris Kaercheri D. W.
Sphenopteris simulans D. W.
Sphenopteris asplenioides Sternb.
Sphenopteris sp.
Sphenopteris dadeana D. W.
Sphenopteris divaricata (Goepp.) Geim. & Gutb.
Sphenopteris (Renaultia) microcarpa Lx. var. dissecta D. W.
Sphenopteris Harttii Dn.
Sphenopteris subpinnatifida D. W.
Sphenopteris Monahani D. W.
Sphenopteris (Diplothmema) patentissima (Ett.) Schimp.
Sphenopteris (Diplothmema) furcata Brongn.
Sphenopteris Royi Lx.
Sphenopteris novalincolniana D. W.
Sphenopteris novalincolniana var. antecedens D. W.
Sphenopteris palmatiloba D. W.
Sphenopteris palmatiloba var. squarrosa D. W.
Sphenopteris Lutheriana D. W.
Sphenopteris mixtilis D. W.
Sphenopteris pilosa Dn.
Zeilleria cf. avoldensis Stur.
Aloiopteris (Corynepteris) georgiana (Lx.).
Oligocarpia crenulata D. W.
Oligocarpia alabamensis Lx.
Pecopteris serrulata Hartt (non Heer).
Pecopteris sp.
Alethopteris Lacoei D. W.
Alethopteris protaquilina D. W.
Alethopteris lonchitica (Schloth.) Brongn.
Alethopteris lonchitica var. multinervis D. W.
Alethopteris alata D. W.
Alethopteris lincolniana D. W.
Alethopteris magnifolia D. W.
Alethopteris grandifolia Newb.
Alethopteris discrepans Dn.
Alethopteris composita D. W.
Alethopteris Serlii (Brongn.) Goepp.
Alethopteris coxtoniana D. W.
Alethopteris Evansii Lx.
Alethopteris Evansii var. grandis D. W.
Alethopteris sp.
Callipteridium alleghaniense D. W.
Callipteridium suspectum D. W.
Callipteridium pottsvillense D. W.
Megalopteris plumosa D. W.
Megalopteris sp.
Neriopteris lanceolata Newb.
Neuropteris Pocahontas D. W.
Neuropteris Pocahontas var. pentias D. W.
Neuropteris Pocahontas var. inaequalis D. W.
Neuropteris Smithsii Lx.
Neuropteris Aldrichi (Lx.).
Neuropteris Elrodi Lx.
Neuropteris acutimontana D. W.
Neuropteris tennesseeana Lx. MSS.
Neuropteris tenuifolia (Schloth.) Brongn. var. humilis D. W.
Neuropteris sp.
Neuropteris aff. heterophylla Brongn.
Neuropteris ovata Hoffm.
Neuropteris hirsutina D. W.
Neuropteris Desorii Lx.?
Neuropteris fimbriata Lx.
Neuropteris gigantea Sternb.
Neuropteris lunata D. W.

Asterocalamites scrobiculatus (Schloth.) Zeill.
Calamites Roemeri Goepp.
Calamites Haueri Stur.
Calamites approximatus Schloth.
Asterophyllites parvulus Dn.
Asterophyllites arkansanus D. W.
Asterophyllites pennsylvanicus D. W.
Asterophyllites cf. rigidus (Stb.) Brongn.
Annularia platiradiata Lx. MSS.?
Annularia laxa Dn.
Annularia acicularis Dn.
Annularia cuspidata Lx.
Annularia latifolia (Dn.) Kidst.
Calamostachys cf. lanceolata Lx. ?
Calamostachys Knowltoniana D. W.
Palæostachya alabamensis D. W.
Macrostachya sp.
Volkmannia crassa Lx.
Sphenophyllum tenerrimum Ett. var. elongatum D. W.
Sphenophyllum bifurcatum Lx.
Sphenophyllum cuneifolium (Stb.) Zeill.
Sphenophyllum tenue D. W.
Bowmannites ? sp.
Lepidodendron alabamense D. W.
Lepidodendron Veltheimii Sternb.
Lepidodendron clypeatum Lx.
Lepidophloios acutomontanus D. W.
Lepidophloios sp.
Lepidostrobus pennsylvanicus D. W.
Lepidostrobus cf. ornatus L. & H.
Lepidophyllum quinnimontanum D. W.
Lepidophyllum campbellianum Lx.
Lepidophyllum lanceolatum L. & H. var. virginianum D. W.
Lepidophyllum linearifolium Lx.?
Lepidocystis fraxiniformis Lx.
Triletes sp.
Bothrodendron arborescens (Lx.).
Sigillaria ichtyolepis (Presl) Corda.
Sigillaria kalmiana D. W.
Sigillaria lincolniana D. W.
Sigillaria cf. lævigata Brongn.
Sigillaria sp.
Sigillariostrobus ? incertus D. W.
Stigmaria verrucosa (Mart.) S. A. Mill.
Stigmariopsis Harveyi Lx. MSS.
Cordaites Robbii Dn.
Cordaites Phillipsi D. W.
Cordaites angustifolius Dn.
Cordaites grandifolius Lx.
Artisia irregularis D. W.
Cordaianthus spicatus Lx.
Cardiocarpon bicuspidatum (Stb.) Newb.
Cardiocarpon bicuspidatum var. ohioense D. W.
Cardiocarpon Cuyahogæ D. W.
Cardiocarpon minus Newb.
Cardiocarpon late-alatum Lx.
Cardiocarpon disculum D. W.
Cardiocarpon orbiculare Ett.
Cardiocarpon cornutum Dn.
Cardiocarpon elongatum Newb.
Cardiocarpon elongatum var. intermedium D. W.
Cardiocarpon annulatum Newb.
Cardiocarpon Phillipsi D. W.
Cardiocarpon Wilcoxi D. W.
Cardiocarpon Girtyi D. W.
Cardiocarpon obliquum Dn.
Trigonocarpum Noeggerathi (Sternb.) Brongn.
Trigonocarpum ampullæforme Lx.
Trigonocarpum Helenæ D. W.
Trigonocarpum Dawsonianum D. W.
Trigonocarpum ornatum Newb.
Rhabdocarpos (Pachytesta) speciosus D. W.
Rhabdocarpos (Pachytesta) Walcottianus D. W.
Whittleseya Campbelli D. W.
Whittleseya Lescuriana D. W.
Whittleseya microphylla Lx.
Whittleseya elegans Newb. var. minor D. W.
Carpolithes fragarioides Newb.
Carpolithes orizæformis Lx. MSS.
Carpolithes sp.
Carpolithes transsectus Lx.
Sporangites sp.
Fayolia sp.

NOTES ON CERTAIN OF THE PREVIOUSLY KNOWN SPECIES, AND DESCRIPTIONS OF THE STRATIGRAPHICALLY MOST IMPORTANT FORMS.

ANEIMITES POTTSVILLENSIS sp. nov.

Pl. CXC, Figs. 1, 2.

Fronds lax, bi- or tri- (?) pinnate; pinnæ slender, slightly flexuose or subgeniculate, loose, slightly irregular, with very slender, sulcate, lineate, narrowly bordered (?) rachis.

Pinnules alternate, distant, open near the base, oblique above, polymorphous, usually asymmetrically ovate or rhomboidal-ovate, sometimes obovate, obtuse, 7 to 18 mm. long, 3 to 11 mm. wide, the lower ones neuropteroid or even triangulo-semicircular, the terminal pinnules cuneate-obovate, generally broad and truncate-rounded, the lowermost sometimes dissected to the base to form young pinnæ of three pinnules, of which the middle one is similar to the ordinary terminal ones, the lateral being rhomboidal, all the pinnules being constricted to a very narrow point of attachment, with straight proximal margins, and very finely lineate lamina between the nerves.

Nervation a little coarse, radiating flabellately from a single basal fascicle, forking three to five times while passing straight to the border, and counting about 25 to the centimeter along the distal margin.

The most common form of pinnule met in the fragments of this polymorphous species is the rhomboidal type, such as is shown in Pl. CXC, Fig. 2, which represents the normal lateral pinnule. In this illustration, which will be supplemented by others in the larger work, the characteristic rhomboidal shape is very imperfectly shown. The sides, especially the superior proximal and the inferior distal margins, are in general nearly parallel. The distal angle is nearly always well marked except in the terminal pinnules, which are cuneate and roundly truncate. An example of the last is seen in Pl. CXC, Fig. 1.

Of the species heretofore published, that to which our species is most similar and most nearly related is *Aneimites adiantoides* (L. and H.) Ett. The extremely close affinity of these two forms may be readily noted by a comparison of the original figure of *Sphenopteris adiantoides*,[1] or that described by Sauveur[2] as *Sphenopteris obtusiloba*, with the specimens in hand.

The Pottsville plant seems to be distinguished from the fern from the Jarrow colliery by its more rhomboidal and angular lateral pinnules, the less dilated or capitate terminals, and, to judge from the figure in the Fossil Flora, by the rather closer, more rigid nervation. One of the specimens from the Culm, figured by Dr. Stur as

[1] Lindley & Hutton, Foss. Fl. Gt. Brit., Vol. II, pl. cxv.
[2] Vég. foss. terr. houill. Belgique, pl. xxv.

Adiantites tennifolius (Ett.) Stur,[1] is also very suggestive of the American species. Still another species from the coal fields of southern Europe, *Aneimites* (*Cyclopteris*) *rhomboidea* Ett. sp.,[2] whose lateral pinnules are very much like some of those in the Pennsylvania plant, has very different terminals, while the lateral ones are more lanceolate.

Aneimites pottsvillensis, which in the Southern Anthracite field has been found only in the roof of Lykens coal No. 4, appears to constitute one of the characteristic species of the upper zone of the Lower Lykens division or Horsepen group (Clark formation), where, in southwestern Virginia and West Virginia, it is represented by numerous examples either identical or differing but slightly. The species occurs at the Old Lincoln mine; roof of the Lykens coal No. 4.

Eremopteris dissecta Lx.

One of the most interesting species of *Eremopteris* in the Southern Anthracite field is the *Eremopteris dissecta* described by Lesquereux[3] from the Pottsville series at the Helena mines in Alabama. It is, in general, characteristic of the Sewanee zone in the Upper Division of the Pottsville series. In the Pottsville Gap this species occurs at a horizon probably 380 feet below the Twin coal.

Eremopteris lincolniana sp. nov.

Pl. CXCII, Figs. 1, 1a.

Pinnæ compound, somewhat geniculate, very open, slightly lax; penultimate pinnæ alternate, open, the lowermost at nearly a right angle or slightly reflexed, the upper somewhat oblique, usually a little distant, rather slender, slightly rigid, though often curved, linear or linear-lanceolate; ultimate pinnæ or compound pinnules alternate, very open below, rather oblique above, usually hardly touching, generally triangular, the lowest very broadly triangular, approaching a palmate form, the uppermost often rather narrow, very deeply dissected into compound lobes or subdivided pinnules, slightly decurrent at the narrow attachment, and bordering the very slightly flexuose and ventrally canaliculate rachis by a narrow wing; subdivisions or compound lobes separated to near the rachis, hardly touching, affecting a slightly trifoliate arrangement, inflated, usually rather broadly cuneate or obovate-cuneate, laterally more or less distinctly convex, obtuse or obliquely denticulo-truncate at the apex, or cut, often obscurely, in two or three unequal, short, obtuse teeth, the apical lobes becoming, especially near the apex of the pinna, sublobate or sometimes narrow; lamina not very thick, dull, somewhat inflated between the nerves, and distinctly so at the margins of the normally disposed specimens.

[1] Culm-Flora, Vol. I, p. 65, pl. xvi, fig. 7.
[2] Steinkohlenfl. v. Stradonitz, 1852, p. 12, pl. ii, fig. 5.
[3] Coal Flora Atlas, p. 9, pl. liii, fig. 4; text (1880), p. 293.

Nervation distinct, smooth, depressed in the lower portions of the pinnules; primary nerve rather coarse, distinctly derived somewhat obliquely from the depressed axis of the rachis, forking at a more or less open angle in the base of each lobe or division, and passing with very slight geniculation, while diminishing, to its vanishment at the apex of the pinnule; nervil of each compound lobe or division forking pinnately at a rather open angle, usually in the lower part of the division, to supply a nerve for each ultimate lobe or tooth.

The plant described above differs from other species of the genus yet known to me by its relatively short, broad, laterally convex ultimate divisions, which are, nevertheless, well separated. The final pinnæ are relatively short and compact. This feature as well as the form of the lobes, which in the inferior basal pinnules are sometimes palmately spread, as in *Eremopteris missouriensis* Lx., is one of the more prominent characters by which the plant differs from *Eremopteris artemisiæfolia* (Brongn), to which, as identified in our American collections, *E. lincolniana* is closely related, or possibly ancestral.

Although from the habit and mode of division of the tertiary pinnæ the fern is apparently referable to the Sphenopteroid division of the genus *Eremopteris*, the basal ramification, so far as it can be determined from the specimens before me, imparts a suspicion that the frond of this species, like that from Missouri, may divide in the same manner as the fronds of *Diplothmema*. As stated in the discussion of the ferns from the Lower Coal Measures of Missouri, I believe both species to have been derived from the Archæopteroid stock through the genus *Triphyllopteris*. It seems far from improbable that *Eremopteris*, *Rhacopteris*, *Ancimites*, *Asplenites*, *Sphenopteridium dissectum* (Goepp.) Schimp., and *Sphenopteris excelsa* L. and H. are members of an early comprehensive group of Paleozoic ferns.

This species has not yet been found above the top of the Pottsville series, although it appears to occupy a period near the close of that formation, and to be most closely related to an undescribed form in the lower portion of the Kanawha series in West Virginia. The type specimens are from the New Lincoln mine, where its association in the matrix with *Neuropteris Elrodi* Lx. renders it nearly certain that it comes from Lykens coal No. 2 or No. 3, probably No. 2. With it is also found the *E. Lehmanni*. *E. lincolniana* is also present from the Lincoln mine, where it is associated with the same species as at New Lincoln. In the Pottsville Gap the species occurs 550 feet below the Twin coal; i. e., near the supposed horizon of Lykens coal No. 3.

Eremopteris Cheathami Lx.

This plant, described by Lesquereux from Rockwood and Tracy City, Tennessee, is one of the most clearly marked and well differentiated fern species of the entire formation. Its most prominent features

are the relatively short, remote, ultimate pinnæ, the minutely rugose-striate limb, and the broadly cuneate, compact pinnules and lobes, cut on the oblique distal margins into short, irregular, blunt, claw-like, erect teeth. Unfortunately the presence of the latter, concealed for the most part by their backward curvature in the matrix of the type specimens, is almost wholly ignored in the figures, accompanied by details, published in the Coal Flora.[1]

The pinnules of the species vary conspicuously in size, the largest seen, in terminal fragments, being nearly one-fourth larger than those figured, while the smallest fragment yet observed is that illustrated in pl. civ., fig. 3, of the Coal Flora. The specimens from 550 feet below the Twin coal in the Pottsville Gap are specifically indistinguishable from the typical Tennessee form, though the northern representatives of the species seem more delicate and less coriaceous than the southern originals.

In our Paleozoic plant collections *Eremopteris Cheathami* has sometimes been confounded with *E. decipiens* on the one hand and *Triphyllopteris Lescuriana* (Meek) Schimp. on the other hand. The species described by Meek from the Pocono or Vespertine series, which, judged by its flora, is nearly contemporaneous with and certainly not later than the Calciferous sandstones of Scotland, is easily distinguished by its clearly lanceolate pinnules or lobes, which are often slightly fasciculate in the impression, the Archæopteroid nervation, and the margins not crenulate or sinuate. Besides its occurrence at the Pottsville Gap this species is also found at the horizon of Lykens coal No. 3 at the Lincoln mine.

Eremopteris decipiens (Lx.)

The form which I have described as *Eremopteris decipiens* (Lx.) constitutes, with its several variations near the top of the Pottsville series in northern Tennessee, in southern West Virginia, and in Arkansas, one of the most interesting types of our upper Pottsville flora, combining as it does, in its general aspect, some of the characters of the broad-lobed species of *Eremopteris* with other details common in certain forms of *Pseudopecopteris*. In the general habit of the lower or pinnatifid pinnules of the frond it is distinctly a member of the group represented by *Eremopteris Cheathami* Lx. The flabellate-cuneate mode of division of the pinnatifid ovate-triangular pinnules or young pinnæ, as well as the emarginate-sublobate upper borders of the lobes, bind the plant to the above-named group, although the nervation, which is also consonant with the latter, is seen to develop the Pseudopecopteroid type in the more broadly dilated, trifoliate forms. Among the hitherto-published American types our species is probably most nearly related to the plants figured or identified as *Pseudopecopteris macilenta*

[1] Vol. III, pl. civ., figs. 2–4, p. 770.

[Lx.], from one form of which the differentiation is hardly more than varietal in importance.

Eremopteris decipiens differs from *Eremopteris Cheathami*, typically represented in abundant material from Tracy City, Tennessee, by the generally more distant and more distinctly cuneate lobes, which are always crenulate-denticulate along the distal margin, by the rather straighter nerves, and by the generally somewhat larger lobes of the latter. *E. Cheathami*, which seems also to be present in the anthracite region, occupies there, as is usually the case in other regions, a somewhat lower stage than the Pseudopecopteroid group.

The species occurs at both the Lincoln mines, at the North Brookside slope, near Good Spring, and at the prospect drift, near the mouth of the upper Eureka tunnel, as well as at several horizons in the Upper Lykens division at the Pottsville Gap.

Mariopteris eremopteroides sp. nov.

Pl. CLXXXIX, Figs. 1, 2, 3, 3a.

Frond quadripartite(?), polypinnate, very large, rather dense; primary pinnæ large, very long, of unknown form, with lineate rachis attaining a diameter of 1.5 cm. or more; secondary (?) pinnæ alternate, open, often at a right angle to the rachis, close, sometimes overlapping nearly one-third their width, linear, or linear-lanceolate, tapering to an acute apex, with rather slender, ventrally concave, dorsally terete, very finely lineate, slightly flexuose or flexuose-geniculate rachis; penultimate pinnæ alternate, open nearly if not quite at a right angle to the rachis, close, usually touching, or slightly overlapping, but sometimes, especially in the upper part of the pinna, a little distant, lanceolate or linear-lanceolate, acute, hardly constricted at the base, slightly flexuose-subgeniculate, the lower inferior pinna not specially heteromorphous; ultimate pinnæ alternate, or sub-opposite, open, often nearly at a right angle to the rachis, close, generally touching or slightly overlapping, the smaller and basal ones triangular-ovate, inequilateral, sometimes broadly deltoid, compact, and but little constricted at the bases, becoming lanceolate, somewhat acute, generally slightly subfalcate, the apices inclined upward, the rachis round-sulcate, ventrally terete, dorsally minutely lineate, and bordered by a narrow wing decurring from the limb of the pinnules.

Pinnules alternate, very oblique or nearly erect in the younger pinnæ, distinct to near the apex of the larger pinnæ, close, generally ovate or rhomboidal, rarely obovate, obtuse or obtusely rounded, the upper ones connate for a little distance, the terminal ovate or ovate-triangular, obtuse, obscurely sublobate, the lower ones attached by very broad, oblique, often produced bases, only the lowest lobed pinnules becoming pinnatifid, they being narrowly constricted at

the bases, all the pinnules showing at an early stage a marked tendency to division in two to five obtuse, rounded lobes, which, appearing at first as one or two rounded teeth a little above the middle, are gradually cut one-half way to the rachis, sometimes, especially in the somewhat heteromorphous basal pinnules, appearing slighly obovate as the pinnule becomes pinnatifid in its development into a pinna, though generally the ovate or ovate-rhomboidal form, with confluent or hardly constricted bases, is preserved to an advanced stage; lamina of the pinnules not thick, very slightly depressed over the primary nerve in the pinnatifid pinnules, very faintly rugose, especially on the dorsal, minutely striated, surface, and rolled rather strongly backward at the margins so as frequently to make the pinnules or lobes appear more acute than they really are.

Nervation of moderate strength, distinct and very slightly depressed on the ventral surface, very close and in relief on the dorsal surface of the pinnule; primary nerve originating at a narrow angle, nearly opposite the proximal basal sinus of the pinnule, forking at an open angle near its point of origin, and curving strongly outward in the base of the pinnule, then forking pinnately and a little widely to supply a secondary nerve for each lobe, the secondary nerves forking one to four times, at a moderate angle, in passing, a little distant, in a gentle, slight curve to the distal border.

The relation of this graceful and beautiful fern to the genus *Mariopteris* appears to be shown by the development of the frond as well as by the general details of the pinnæ. Nevertheless, the aspect of the pinnatifid portions of the frond, particularly when seen in small fragments, showing the spreading, lobed, relatively unconstricted, extended pinnules, such as that shown in Pl. CLXXXIX, Fig. 3, as well as the nervation, is often so similar to the corresponding parts in some of the smaller, more compact forms of *Eremopteris* as to call in question its generic attitude to the latter. The examination of a large series of specimens shows the species in hand to be, however, one of easily recognized individuality. The very large size of the plant is evidenced by portions of its rachis over 3 cm. in diameter, fragments of rachis, apparently representing one of the larger of the four divisions of the frond, being about 1.5 cm. in diameter when compressed. The rachises of the lateral pinnæ are more slender than in most species of this genus, and are slightly flexuose, in correspondence with the pinnation, even where the axes have attained considerable development.

The salient features which are to be observed at the first glance at small fragments of the fern are a relatively close pinnation, with a tendency to curve upward in the smaller pinnæ, the closeness or connateness of the obtuse pinnules, and the marked tendency to lobation, which shows even in the small and half-developed pinnules, the lobes appearing as one or two or three inconspicuous shoulders, or

broad, obtuse, or rounded teeth on the sides of the limb. When further developed this sublobation, which may be seen in specimens from nearly every part of the frond, becomes conspicuous, giving the pinnule in its pinnatifid stage a Sphenopteroid or Eremopteroid phase.

Probably the only species of the genus in our flora with which *Mariopteris eremopteroides* is liable to be confused is *M. pottsvillea*. But although there is a resemblance in portions of the fronds of the two species, sometimes appearing close on a casual glance, it is rarely difficult to distinguish the two forms, even in small fragments bearing simple pinnules, from the upper part of the penultimate pinnæ. The pinnules of *M. eremopteroides* are not so constricted at the base, not so triangular or dilated just above the point of attachment, and, as may almost invariably be noted, they are more or less distinctly lobate or sublobate, even in a younger stage, in which they are still attached by the whole base or even slightly connate. In general, the short pinnæ of the latter species are more dilated toward the base, both the pinnæ and the pinnules being usually smaller, the latter being more frequently connate, as well as lobate and alate. Very often, too, the pinnules are set out from the rachis by a slight elongation of the basal portion or attachment so as to suggest a very short, broad pedicel, sometimes nearly equaling the pinnule in width. The nervation of *M. pottsvillea* is somewhat coarser and noticeably more distant and arched.

The species is abundant at all mines in the horizon of the roof shales of Lykens coal No. 5. Possibly it is present also in the roof of Lykens coal No. 6.

Mariopteris pottsvillea sp. nov.

Pl. CXC, Figs. 3, 3a, 4, 4a, 5, 6.

Fronds quadri- or poly- (?) pinnate, robust, not very dense; penultimate pinnæ alternate, open, the lower at a right angle to the rachis, the upper slightly oblique, rather distant, lanceolate, or linear-lanceolate, slightly contracted at the base; rachis somewhat flexuose, coarsely lineate in the major divisions, more finely and irregularly lineate in the smaller divisions, while in the penultimate and ultimate pinnæ they are slender, slightly flexuose-geniculate, ventrally sulcate, dorsally round, and broadened by narrow decurrent wings of the lamina; ultimate pinnæ alternate or subopposite, open at a right angle or slightly oblique, distant, usually one-half their width or more apart, lanceolate or linear-lanceolate, clearly constricted at the base, with a narrow decurring border.

Pinnules alternate or subalternate, usually distant, oblique, broadly ovate, or ovate-triangular, asymmetrical, obtuse, or obtusely rounded, ventrally arched, distinctly constricted at the broad base, which is marked in all the well-developed examples by an inferior rounded sinus, the uppermost pinnules becoming confluent, more oblique and

rounded, blending into the rather long terminal, which often has its obscurely sublobate or sinuate margins rolled back so as to make it appear acute or even muricate; lamina of the pinnules not very thick, dull, becoming decurrent in a very narrow wing along the rachis.

Nervation rather strong, distinct; primary nerve originating low at an acute angle, arching outward, not rigid, forking repeatedly at a moderately wide angle; nervils a little distant, forking one to three times and curving more or less in passing, with diminishing distinctness, to the margin.

The examination of the collections from the geological sections of the Pottsville series, from Pottsville in Pennsylvania to the southern extremity of the Appalachian coal field in Alabama, shows the species described above, with its minor variations, to be one of the most ubiquitous as well as the earliest American representatives of the genus *Mariopteris*. Under the name *Pseudopecopteris muricata* (Schloth.) Lx., it has long been known in the collections from the whetstone beds of Indiana, the Dade coal (Lookout sandstone of Hayes) in Georgia and various points in Alabama. Recent studies in the field show it to be specially prevalent in the middle division of the Pottsville series, to which I have given the name Horsepen group. It is more particularly characteristic of the upper part of this group.

The ordinary ultimate divisions of *Mariopteris pottsvillea*, such as are illustrated in Pl. CXC, Fig. 4, are clearly characterized (1) by the comparative remoteness of the pinnæ and pinnules; (2) by the form of the pinnules, which are broadly ovate, obtuse or obtusely rounded at the apex, dilated above the base, and plainly constricted at the base, and arched ventrally; (3) by the large size of the pinnules, which is greater than any of the earlier round-ovate, inflated-pinnuled forms yet found in what may for convenience be called the *Mariopteris muricata* group; and, finally, by (4) the rather coarse, distinct, curved, rather close nervation, which approaches near to that of *Mariopteris tennesseeana*, a form intermediate between *M. pottsvillea* and *M. muricata* or *M. nervosa*.

The present status of *Filicites muricatus* Schlotheim,[1] or of the types of Brongniart's *Pecopteris muricata*,[2] seems slightly ambiguous, since the *P. muricata* has latterly been united by Zeiller[3] and other European paleobotanists with *Mariopteris nervosa* (Brongn.) Zeill., a form quite distinct from the American material hitherto recognized as Schlotheim's species.

It is true that the difference between the forms originally described under the two names is much less than we have been led to believe from the American interpretations of the illustrations and figures.

[1] Petrefactenk., p. 409; Flora d. Vorwelt, pl. xii, figs. 21, 23.
[2] Hist. vég. foss., Vol. I, p. 352, pl. xcv, fig. 34; pl. xcvii, fig. 1.
[3] Fl. Foss. bassin houill. Valenciennes, p. 173.

Still, while there is scarcely room for doubt that *M. nervosa* was either derived from *M. muricata* or a common, slightly earlier stock, the analogies of the vertical distribution of the American species of *Mariopteris* lead naturally to the expectation that the latter type will be found to occur considerably lower in the stratigraphic series of Europe and to disappear much earlier than the former, although through a portion of the Coal Measures they may have existed side by side. In the American sections the form designated in this report *M. tennesseeana*, which is possibly nearest to the plant figured as *Pecopteris muricata* by Brongniart, predominates at the base of the Sewanee group and hardly survives in the normal type to mingle with the small, delicate, thin-nerved variety which appears, in the American Carboniferous, to be the earliest representative of *M. nervosa*, occurring in the uppermost portion of the Pottsville series.

The relations of *Mariopteris muricata* and the type designated in our American literature *M. nervosa* have been specially discussed in my remarks on the forms occurring in the McAlester, Indian Territory, coal field.[1]

The characters enumerated above readily distinguish *Mariopteris pottsvillea* from those European forms known as *M. muricata* and *M. nervosa*. The form typically described in the American literature as *Pseudopecopteris nervosa* (Brongn.) Lx. has larger, broad, triangular, acute, closer, unconstricted pinnules, with much stronger, more distant, straighter nerves. The species described in manuscript by Dr. Newberry as *Pecopteris inflata* is a much smaller plant, with sessile, close, thin pinnules and finer nervation. Finally, *M. tennesseeana* is a more robust fern, with compact, close pinnules or lobes, the upper ones confluent, very oblique, and not so contracted at the base.

This species is common at all localities in the horizon of the roof shales of Lykens coal No. 4, and is apparently unknown at any considerable distance from that level.

The plant is found in good examples at the Lincoln mine, the Brookside mines, Williamstown, the upper Eureka drift, and in a shaft about 200 yards northeast of the north Brookside slope, Good Spring; at the Broad Mountain mines, at Swatara Gap, and in the Pottsville Gap.

Mariopteris pygmæa sp. nov.

Pl. CXCII, Fig. 2–6.

Frond small, compact; rachis relatively strong, lineate, deeply depressed, ventrally canaliculate; penultimate pinnæ alternate, nearly at a right angle to the rachis, close, touching or overlapping, lanceolate or linear-lanceolate, acute or acuminate; ultimate pinnæ alternate,

[1] Nineteenth Ann. Rept. U. S. Geol. Survey, Pt. III, p. 475.

very compact, very open, usually touching or slightly overlapping, lanceolate or oblong-lanceolate, acute or sometimes obtusely acute, somewhat rigid.

Pinnules very small, 1.25 to 8 mm. long, 1 to 6 mm. wide, alternate, usually contiguous or slightly overlapping, crowded, very highly inflated, generally ovate, the lowest reniform-ovate, slightly distally apiculate, dilated near the base, conspicuously constricted at the inferior side of the rather broad attachment, those of the middle portions dilated-ovate or ovate-triangular, apiculate or obtuse, the terminal usually short and obtuse or apiculate, or, at the end of the penultimate pinnæ, slightly sinuate-margined, acute or mucronate; lamina thick, very much inflated or arched and smooth ventrally, the margins curving strongly backward, and decurring in a narrow wing along the rachis.

Nervation rather coarse, the nervils concealed on the ventral surface, but somewhat distinct on the concave dorsal surface of the pinnules; primary nerve strong, originating at a narrow angle and sharply marked in the largest pinnules by a vanishing furrow on the ventral surface of the lamina; nervils originating at a rather narrow angle, those in the lower part of the pinnule arching near the primary nerve, and passing, straight or curved, relatively close together, the lower ones forking once, or rarely twice, the upper nervils often simple.

This, the smallest form of the *Mariopteris* group known to me, is unique not only for the minuteness of its pinnules, but for the degree of their inflation and for the crowded arrangement of the pinnules and pinnæ. The fragments represented in Pl. CXCII, Figs. 2–6, are of the average form and size, such examples being abundantly dispersed on some of the shale slabs from the Lincoln mine.

Both *Mariopteris pygmæa* and *M. Phillipsi* belong to a group of small forms of *Mariopteris* that is almost exclusively confined to the Sewanee or Upper Lykens division of the Pottsville series. The smallest representatives are seldom found outside of the uppermost beds of the Sewanee division. The fern from the Tremont region, which is hardly more than varietally different from a form abundant in the roof shales at Lemon's coal mine, in the "coal-bearing shale" of Washington County, Arkansas, is evidently closely related to that described in manuscript by Dr. Newberry as *Pecopteris inflata* from the Sharon coal of northeastern Ohio. Both plants, each of which is very abundant in its own localities, are very rarely found at the same locality, *M. inflata* being generally confined to lower beds in the Sewanee zone.

The genetic relations of the plant from New Lincoln and that from the Sharon coal are corroboratively indicated in the Pottsville Basin itself by the presence of the Arkansas form mentioned above in the rock dump at New Lincoln. The latter is distinguished from the normal *M. pygmæa* by the rather larger, thinner, less inflated, more

strongly apiculate pinnules, the nervation being clearer on the ventral surface.

This singular little species is nearly always found in abundance associated with *Neuropteris Elrodi* L., *Methopteris Lacoei*, and *Sphenophyllum tenerrimum* Ett. var. *elongatum* in the roof shales of Lykens coal No. 2. It has been collected at the lower Eureka drift, the old Lincoln mine, the New Lincoln mine, and at the corresponding horizon in the type section at Pottsville.

Mariopteris tennesseeana sp. nov.

The fossils which I shall eventually describe in full as *Mariopteris tennesseeana* comprise the unpublished Tennessee material included by Lesquereux in *Pseudopecopteris dimorpha*.

The comparison of the specimens from the horizon of the Sewanee coal at Rockwood, Tennessee, and from the zone of Lykens coals Nos. 2 and 3 in the Southern Anthracite field, with the specimens from the higher Coal Measures at Mount Hope, Rhode Island, and Oliphant, Pennsylvania, which constitute the originals of the species, shows the former to be undoubtedly specifically distinct. They are easily recognized by the open, a little distant, constricted pinnæ, and especially by the obtuse or rounded pinnules, generally ovate-triangular in form, distinctly oblique, never constricted at the base except in the largest, which are becoming pinnatifid; and, though separated almost to the base in the lower portion of the pinnæ, they are seen to be more and more broadly confluent in passing upward, blending in the obtusely sublobate, usually rather blunt terminal portion of the pinnæ. The Tennessee species is further distinguished by the not very strong nervation, which is usually indistinct beneath the rather thick epidermis.

This species occurs in its normal form or as a variety in the Sewanee zone at the Lincoln mine and in the Pottsville Gap.

Sphenopteris Kaercheri sp. nov.

Under this name I have described a fern which, in pinnation, size, and general form and arrangement of the pinnules very closely resembles *Eremopteris microphylla* of Lesquereux, from beds presumably in the Sewanee zone at the Helena mines in Alabama. The salient features of this species are the slender pinnæ, the oblique, distant, slightly irregular, somewhat Eremopteroid, often trifoliate pinnules, and the moderately straight and nearly parallel nerves, which are often concealed by the interneural striation of the somewhat inflated limb.

The plant is found at both the Pottsville Gap and at the New Lincoln mine, where it is associated with *Neuropteris Elrodi*, *Sphenophyllum tenerrimum* and *Eremopteris lincolniana*, species indicative of the horizon of the roof of Lykens coal No. 2.

Sphenopteris asplenioides Sternb.

It is much to be regretted that a consistent observance of the law of priority in nomenclature appears to necessitate the use of *Sphenopteris asplenioides* Sternberg in place of the more familiar name *Sphenopteris Hæninghausi* Brongn., under which the former name is inscribed by most authors as a synonym.

Although the species seems, in the Southern Anthracite field, to be very rare in the zone of Lykens coals Nos. 2 and 3, its more common occurrence being in the roof shales of Lykens coal No. 4, in the Lower Lykens division, it has generally a wide range in the thick sections of the Pottsville in the Southern Appalachian region. In the Clark formation, below which it does not yet seem to have been found, the fern is represented by a form with small, compact, round-lobed pinnules and very narrow pinnæ, close to if not identical with *Sphenopteris dicksonioides* Stur, with which it was identified by Professor Lesquereux. In the Quinnimont formation the species becomes developed in its typical form, the plant being abundant and of large size. Above this stage of the Pottsville, in the Sewanee zone, or the Sewell formation, which, as we have seen, is essentially contemporaneous with the flora of the zone of the Lykens coals Nos. 2 and 3, this species is found in a more robust phase, with elongated lobes of the pinnules, often resembling *Sphenopteris elegans*, to which it seems to bear a genetic relation. From this large, cuneate-lobed form, in the upper part of the Sewell formation, the species seems to have very rapidly waned, so that, in the overlying Fayette formation in the Virginia region, it is but very rarely met, and then in a depauperate condition. The fructification on the lobes of the typical form of *Sphenopteris asplenioides* is probably referable to the genus *Renaultia*. As such it may be regarded as generically identical with *Sphenopteris microcarpa* Lx., which it resembles in its punctate rachis and the mode of the development of its pinnules.

In the Southern Anthracite field this species is found chiefly in the horizon of the roof shales of Lykens coal No. 4, at East Brookside, and the Lincoln collieries. Examples of a very small form are present in the roof shales of Lykens coal No. 5 at Williamstown and Big Lick, while the normal form is present in the Pottsville Gap.

Sphenopteris dadeana sp. nov.

The specimens which will eventually be described as *Sphenopteris dadeana* comprise several of the types which were included by Lesquereux under the name *Sphenopteris Gravenhorstii* var. *β* Brongn. They differ from the examples figured under the above name[1] by the

[1] Coal Flora, Vol. III, pl. ci, figs. 1, 1ª, 1ᵇ, p. 763.

punctate rachis, by the broader-lobed, shorter pinnules, the texture of which is more delicate or membranous, and by the relatively simple nervation, the nerves forking more distantly at a narrower angle and curving upward so as often to become nearly parallel in the lobe. The species is quite distinct from the *Sphenopteris fragilis* Sternb., which is cited by Brongniart[1] as a synonym of *Sphenopteris Gravenhorstii*. This plant, which occurs at 710 feet below the Twin coal in the gap at Pottsville, appears to be characteristic of, though of rare occurrence in, the *Mariopteris pottsvillea* zone in the Southern Appalachian region.

Sphenopteris divaricata (Goepp.) Gein. & Guth.

This species probably bears the closest relation to *Sphenopteris asplenioides*, and appears, as represented by specimens in the Scwance zone (Upper Lykens division), to be distinguished from the latter chiefly by the short, thick, obtuse, cuneate, often half-flabellate lobes of its more distant pinnules. Even in small fragments it is much coarser than the Larischiform *Sphenopteris asplenioides*.

Sphenopteris microcarpa Lx.

This fern, which in its typical form appears to be more or less characteristic of the Clark and Quinnimont formations in the Southern States, is represented in the Upper Lykens division, in the Southern Anthracite field, by a very delicate, deeply cut variety, which I have termed *dissecta*. This variety, which occurs at the New Lincoln mine, is also rarely found in the Sewell formation, in the Virginia region.

Sphenopteris Harttii Dn.

The specimens from the New Lincoln mine and from the Pottsville Gap, which I refer to *Sphenopteris Harttii*, appear to agree in all respects with examples of that species from the supposed middle Devonian beds at the type locality, St. John, New Brunswick.

Sphenopteris patentissima (Ett.) Schimp.

Pl. CLXXXVIII, Fig. 1.

Primary pinnæ probably arranged pinnately along an axis; principal divisions bipinnate or tripinnatifid, ovate-triangular or triangular-acute, inequilateral, lax, with relatively slender, more or less flexuose, narrowly alate rachial axis, which is lineate, narrowly sulcate ventrally, subcarinate dorsally; ultimate pinnæ alternate, distant, open, often at a right angle, flexuose, linear or linear-lanceolate, acute, or somewhat obtuse.

Pinnules alternate, usually distant, very open, often nearly at a

[1] Hist. vég. foss., p. 191.

right angle, ovate, round-ovate, or frequently more or less narrowly triangular, elongate and acute, generally briefly subpetiolate, cut alternately to near the base or midrib into one to five close or distant, more or less divergent, cuneate or rhomboidal divisions, which in turn are once or twice deeply or laciniately incised in narrow, simple, bifid or trifid divergent lobes, each simple linear lobe or tooth having its margins parallel or but slightly converging upward to the very narrow, obtusely rounded apex; lamina not very thick, finely longitudinally lineate, apparently by rows of scaly epidermal cells parallel to the nerves, which are often partially obscured.

Nervation usually visible and of moderate strength; primary nerve curving strongly outward from a very acute-angled, decurrent origin, forking low, the divisions forking repeatedly to furnish a single nervil for each lobule or tooth.

Representatives of this interesting species are not rare in the lower portions of the very thick sections of the Pottsville series in the Virginia, Tennessee, and the Alabama regions, as well as in the Southern Anthracite field of Pennsylvania. While, however, the specimens from some of the localities in the Southern Appalachian coal fields are typical of the form delineated by Ettingshausen, the form described above from the collection before me appears to differ slightly from the Old World types[1] by the generally slightly more flexuose pinnæ, a little greater coherence of the lobes, and a rather less marked tendency of the latter to curve outward. In the second particular they are extremely close to the fragments illustrated by Stur.[2] As may be noted in the fragments illustrated in Pl. CLXXXVIII, Fig. 1, considerable difference exists in the form and elongation of the pinnules in different portions of the frond.

The essential characters of the species are the lax habit, the distant, large, very open, and short pedicellate pinnules, the elongated and loose development, with deep, open sinuses, of the subdivisions, and the linear, very blunt or round-pointed lobules which are hardly contracted below the middle. The somewhat irregular lineation seen in the lamina of the Pennsylvania specimens is clearly visible with a weak lens. Frequently the apices are partly buried in the matrix, or the margin is a little revolute, so as to give the lobules a sharp profile on the rock, but when carefully worked out the tip is found to be rounded. The large pinnules seen in Pl. CLXXXVIII, Fig. 1, are comparable to figs. 7 and 8, pl. ix of the first part of the Culm-Flora.

Sphenopteris furcata Brongn., a species whose pinnules resemble those of *S. patentissima*, is distinguished from the latter by the more rigid pinnæ, the closer and more compact pinnæ and pinnules, which

[1] Ettingshausen, Foss. Fl., Mährisch-Schlesischen Dachschiefers, p. 26, pl. vii, fig. 4, text-fig. 13.
[2] Culm-Flora, I: Die Culm-Flora d. Mährisch-Schlesischen Dachschiefers, p. 36, pl. ix, figs. 1–9.

are sessile, often less deeply dissected; and the relatively shorter, less divergent, and frequently slightly constricted lobules of the former species. In *Sphenopteris Royi* the lobules are more oblique, more broadly coherent, and acute. Finally *Sphenopteris patentissima* is in general more characteristic of the Culm or Carboniferous limestone of the Old World or of the lower Pottsville in the New, while *S. furcata*, its probable descendant, is later in its appearance, passing from the upper Pottsville into the Lower Coal Measures.

Sphenopteris patentissima is common in the roof shales of Lykens coal No. 5, and more especially of Lykens coal No. 4, of which it is largely characteristic, at the Brookside and Lincoln mines, as well as at the mines in the Lower Lykens division, on Broad Mountain. It is also present in the zone of Lykens coal No. 4 at the Pottsville Gap.

Sphenopteris (Diplothmema) furcata Brongn.

The examination of the American material belonging to the group represented by *Sphenopteris furcata* shows an interesting series of slight modifications. The earlier forms, characteristic of the uppermost beds of the Pottsville formation, are so closely related to *Sphenopteris Royi* that the two are sometimes difficult to distinguish. The pinnules of the former are, however, generally more dilated, the laciniæ more divergent, acute, and less coherent. The species appears to have diminished in size in the Lower Coal Measures, where it is perhaps inseparable from the type described by Lesquereux as *Sphenopteris trichomanoides* Brongn. Frequently the reduced size and the obliquity of the pinnules and lobes appear to distinctly relate it to *Sphenopteris dissecta* and *S. alata*. The species is readily separated from *Sphenopteris patentissima*, of the Lower Lykens division, by the very distant and deeply palmately lobed lower pinnules of the latter, the lobes being relatively long and hardly contracted near the base. In the Southern Anthracite field, *Sphenopteris furcata* occurs in the upper part of the Sewanee zone at the Pottsville Gap and at the New Lincoln mine.

Sphenopteris Royi Lx.

The salient feature of this species, which was described by Lesquereux,[1] from the roof of the Sewanee coal at Rockwood, Tennessee, is the obliquity of the rather distant, pinnatisect pinnules, whose very narrow lobes are fixed on a somewhat more elongated axis than in *S. furcata*, or *S. patentissima*, while at the same time they are very oblique, tapering from a slightly coherent base to an acuminate point. Superficially, this species seems to be intermediate between *S. alata* on the one hand and *S. furcata* on the other hand. It is found with *S. palmatiloba* at the New Lincoln colliery. A small and doubtful fragment comes from the Upper Lykens division in the Pottsville Gap.

[1] Coal Flora, Vol. III, p. 768, pl. civ, figs. 7–10.

Sphenopteris pilosa Dn.

The specimens, including the types, from the upper portion of the Pottsville in Washington County, Arkansas, described by Lesquereux[1] as *Sphenopteris communis*, appear to present the identical specific characters seen in examples of *Sphenopteris pilosa* from the so-called middle Devonian beds at St. John, New Brunswick. In the Sewanee zone, which includes the Arkansas beds, of which the species is characteristic, we find it associated, as at St. John, with *Pecopteris serrulata*. The specimens from the Southern Anthracite field are found near the supposed horizons of Lykens coals No. 2 or 3, at about 465 feet below the Twin coal, in the gap at Pottsville.

Aloiopteris georgiana (Lx.).

The material described by Lesquereux as *Pecopteris georgiana*[2] is generically identical with the *Aloiopteris Sternbergii*, *A. Winslovii*, and *A. erosa* of the Productive Coal Measures. The species is notable for the great length and proportionate narrowness of the rather distant ultimate pinnæ. The pinnules are nearly always at least tridentate, the primary nerve forking below the middle, and once or twice again in the upper part of the pinnule. The species which is, I believe, the antecedent representative of this group in our American Carboniferous is readily distinguished from *A. Winslovii* by its narrower ultimate pinnæ, the small pinnules, and the coriaceous texture. The pinnules are proportionately a little farther distant, narrower, and distinctly curved, the teeth sharp and directed forward, the nerves curved and strong. Compared with *A. Sternbergii*, the Georgia species is much more cristate, the teeth more acute, the nerves stronger, more open, and more upturned. The normal type is apparently characteristic of the *Mariopteris pottsvillea* zone in the Lookout formation in northwestern Georgia. The specimens in hand are from the roof of Lykens coal No. 4, at the Lincoln colliery.

Oligocarpia alabamensis Lx.

Specimens from the Lincoln colliery agree in all respects with typical material from Helena, Alabama, the original locality of the species. The plant appears to be, on the whole, characteristic of the basal portion of the Sewanee zone, though it may be found in the upper part of the *Mariopteris pottsvillea* zone.

Pecopteris serrulata Hartt.

The representatives of this species in the Pottsville formation appear to be in all respects in agreement with those from the type locality at

[1] Coal Flora, Vol. III, p. 762, pl. xciv, figs. 1 and 1a.
[2] Ibid., p. 759, pl. xcviii, figs. 6 and 6a.

St. John, New Brunswick. With the exception of a few fragments supposed to have come from the roof of Lykens coal No. 4 at Brookside, the species is not known below the Sewanee zone in the United States. Its geographic distribution in this zone is wide, the same form being collected in the shales over the Sharon coal in northwestern Pennsylvania, the Sewell coal in the Virginia region, the Sewanee coal in Tennessee, and in the coal-bearing shale in Washington County, Arkansas. In the upper part of the Sewanee zone this plant appears to merge into the form commonly known as *Pecopteris plumosa* Artis. In fact, in the region of the Fayette formation the latter appears to have succeeded the New Brunswick fern.

Alethopteris Lacoei sp. nov.

Pl. CXCIII, Figs. 1, 2.

Secondary pinnæ linear-lanceolate, very long, acute, slightly narrowed at the base, often gently curved, with a distinctly lineate rachis; ultimate pinnæ of moderate size, usually alternate, but often sub-alternate, sub-opposite, or rarely opposite, open at nearly a right angle to the rachis, usually close, sometimes slightly overlapping, more rarely a little distant, somewhat curved, linear-lanceolate, or linear, tapering to a slender, acute point; rachis finely lineate, rather deeply depressed, strongly concave and canaliculate ventrally, dorsally terete.

Pinnules alternate or sub-alternate, the lowest open nearly to a right angle, close or a little distant, slender, linear-triangular, or ovate-triangular when small, hardly constricted at the base, tapering gently through the lower third, the margins converging a little more rapidly in the upper two-thirds, acute or slightly obtusely pointed, cut to near the rachis with a rather broad, acute sinus, regularly and strongly crenulate-inflated in all portions of the frond; lamina rather thin, very strongly ventrally convex, alternately strongly inflated and transversly depressed at regular intervals of from 1 to 2 mm., according to the size of the pinnules, the margins being often slightly infolded dorsally so as to give the pinnules a tapering acuminate apex.

Nervation distinct, regular; midrib moderately strong, hardly decurrent, straight, deeply depressed, tapering gradually, but distinct to the apex; nervils slender, relatively regular, rather close, hardly decurrent, simple or forking once close to the base, and passing nearly straight and parallel to the border.

Alethopteris Lacoei is one of the smaller or more delicate species of the genus, its form and general proportions being closely comparable to *A. Mantelli*,[1] or the smaller, narrow-pinnuled phases of *A. lonchitica*. It is, however, very well marked by the alternating strong

[1] Brongniart, Hist. vég. foss., p. 278, pl. lxxxiii, figs. 3, 3a, 4.

inflations of the ventrally convex lamina, which gives the margin a slightly sinuate trend. This alternately inflated development of the lamina, suggesting a series of rectangular cushions on either side of the midrib, or the expressions of distant sori through the substance of the fern, is a constant character plainly discernible in all parts of the frond.

The aspect of the larger pinnules is very much like that represented by Brongniart[1] in *Pecopteris marginata*. But, while the resemblance of the undulate surface and sinuate margins is close, the species from Pennsylvania differs by its smaller size, greater delicacy, narrower pinnules, longer and narrower terminals, as well as by the absence of the flat border of the Old World type. Quite independent of the inflation of the lamina, *A. Lacoei* is separable from the *A. Mantelli* and *A. lonchitica* series by the form of the pinnules, which are hardly narrowed at the base, but which taper from the base upward, the apices generally appearing as acute. The nerves, which may fork close to the midrib, are nearly straight and regular in passing at a right angle to the margin, thus differing from those of the *A. Serlii* or *A. grandifolia* types. The latter, however, are too distinct in other respects to require further comparison.

Although this species is common at the horizon of Lykens coal No. 2 in the Southern Anthracite field, it is generally rare in other regions of the Appalachian province. Yet when present it is usually represented by large numbers of individuals. In the anthracite region the species has been found at the New Lincoln mine, the lower Eureka tunnel, and at the supposed horizon of Lykens coal No. 2 in the gap at Pottsville.

Alethopteris protaquilina sp. nov.

The essential features of this species are the small proportions of the pinnæ and the close, very compact, oblong, or linear-lanceolate, obtuse pinnules, in which the limb is of about equal breadth at the base, the terminal being small, rather short, undulate and sub-lobate, while the curved nervation is often concealed within the thick, strongly inflated lamina. The fern belongs to the straight-pinnuled group represented by *A. aquilina*, *A. ambigua*, *A. Gibsoni*, and *A. pennsylvanica*. It is in most cases easily distinguished from the *A. Lacoei* by the tapering, corrugated, more acute, and thicker pinnules of the latter, in which the nervation is more distant. The species is for the most part confined to the roof shales of Lykens coal No. 4, at which horizon it occurs at the Brookside mines and in the Pottsville Gap.

[1] Op. cit., p. 291, pl. lxxxvii, figs. 2, 2a.

Alethopteris lonchitica (Schloth.) Sternb.

The specimens from the roof of the Sharon coal in Ohio, described by Dr. Newberry under the above name, are probably in closer agreement with the original type than any of the other forms that have been identified under the same name from the Allegheny series of this country. Most of the latter are probably referable to *Alethopteris Serlii* or *A. aquilina*. A form with narrow pinnules, sometimes approaching *Alethopteris decurrens*, is found in the coals of the Kanawha series in southern West Virginia. The species is represented by the normal form, or by varieties, in the Upper Lykens division at the Pottsville Gap and at the Lincoln mines.

Alethopteris grandifolia Newb.

This species, described by Newberry[1] from the roof of the Sharon coal, is, in general, characteristic of that horizon throughout the Appalachian province. *Alethopteris Helenæ* Lx. and *Callipteridium Oweni* Lx., both occurring in the Sewanee zone, are so closely related to Newberry's species as to render their specific individuality very doubtful. The group is, in general, characterized by the lax, irregular, and uneven open pinnules, the relatively thin midribs, and the distantly and irregularly flexuose thin nervation. The flora of the Kemble drift constitutes the oldest plant association in which this species has yet been found.

Alethopteris discrepans Dn.

The specimens from the New Lincoln mine, which I refer to Sir William Dawson's species, appear to agree in all respects with specimens from the fern ledges at St. John, New Brunswick. The occurrence of this species, together with *Sphenopteris Harttii*, *S. pilosa*, and *Pecopteris serrulata*, in the Upper Lykens division of the Pottsville formation points strongly to the close relationship between the flora of the latter and that of the supposed middle Devonian beds at St. John, a relationship so close as to convince me that no appreciable difference in age exists between the plant beds at the two localities.

Alethopteris coxtoniana sp. nov.

The material which will be described under this name includes the types provisionally referred by Lesquereux[2] to *Callipteridium Dournaisii*. The originals are from Campbell Ledge, in the Northern Anthracite field. The specimens from the Southern Anthracite field were found in the thin parting of the conglomerates at 245 feet below the

[1] Report Geol. Survey Ohio, 1873, Vol. I, Pt. II, p. 384, pl. xlviii, figs. 1, 1a, and 2.
[2] Coal Flora, Vol. III, p. 717.

Twin coal in the Pottsville Gap, while doubtful fragments, representing a rather more elongated form of pinnule, with rather more distant nerves, come from one of the upper Lykens coals at the New Lincoln mine.

Alethopteris Evansii Lx.

Pl. CXCII, Figs. 7, 7a, 8, 8a.

This species, which was described by Lesquereux[1] from the shales accompanying the Sewanee coal in Tennessee, resembles *Lonchopteris* in the form of its pinnæ and pinnules, while the nervation suggests one of the more oblique-nerved, straight-pinnuled species of *Alethopteris*, or *Callipteridium*. The surface of the lamina is rugose and distinctly, though finely, punctate. The nerves are close, regular, rather oblique, forking once or twice. The normal form of this species appears to be generally confined to the region of the Sewell and Sewanee coals of the Southern Appalachian regions and to the approximate horizon of Lykens coal No. 3, in the Pottsville Gap. A later form, with very much larger, semi-membranous pinnules, occurs at higher horizons in the Sewanee zone, both in Arkansas and in the Southern Anthracite field. Typically, this species occurs 550 feet below the Twin coal in the Pottsville Gap and in the dump from the upper Lykens coals at the Lincoln mine. A variety *grandis* appears to have come from the roof of Lykens coal No. 1, at the latter locality.

Callipteridium pottsvillense sp. nov.

In this species we have one of the composite Pottsville types, presenting at once characters of *Megalopteris* and *Alethopteris*. The pinnules are elongate, acute, and thick, resembling very closely those of *Megalopteris marginata* Lx.[2] It is also apparently related to *Neuropteris lanceolata* of Newberry.[3] The fern is closely allied to *C. tracyanum* Lx., from which it differs by the oblong, acute, or acuminate pinnules, which are more unequal at the base, and the less distant and generally oblique nerves. The plant occurs in the Upper Lykens division in the Pottsville Gap.

Megalopteris plumosa sp. nov.

The species of the rare genus *Megalopteris*, including the *Megalopteris Dawsoni* described from St. John, New Brunswick, appear to be characteristic of the Pottsville formation. Furthermore, the greater number of species thus far described are confined to the Sewanee zone in Arkansas, Tennessee, West Virginia, and Ohio, as well as in

[1] Coal Flora, Vol. III, p. 834.
[2] Idem, Vol. I, p. 152, pl. xxiv, figs. 4, 4a.
[3] Rept. Geol. Survey Ohio, 1873, Vol. I, Pt. II, pp. 378–381, pl. xlv, figs. 1, 2, 3, 3a.

Pennsylvania. The most interesting species of this genus occurring in the Pottsville formation of Pennsylvania, *Megalopteris plumosa*, closely resembles *M. Dawsoni* Hartt from the so-called middle Devonian of New Brunswick. It differs from the latter chiefly by the very oblique nervation. The specimens were obtained from a slope in the Upper Lykens division at Yellow Springs Gap.

Neuropteris Pocahontas sp. nov.

Pl. CLXXXIX, Figs. 4, 4a; Pl. CXCI, Figs. 5, 5a.

Fronds large, tri- or quadri-(?) pinnate, with very broad, strongly lineate, slightly flexuose rachis, which may attain a diameter of 4 cm. or more; penultimate pinnæ generally alternate, open nearly at a right angle, becoming somewhat oblique above, close, often touching or slightly overlapping, linear-lanceolate or linear, very slightly narrowed at the base, the margins nearly parallel in the middle portions, tapering a little rapidly near the top to an acute apex, the ultimate pinnæ being followed by a few large pinnules, rapidly succeeded by a narrow, basally sublobate, small, obtuse, inequilateral, ovate-triangular terminal, the rachis being rather strong, slightly depressed ventrally, lineate, and a little flexuose near the apex; ultimate pinnæ, alternate or subalternate, open at a right angle below, slightly oblique above, usually slightly overlapping or touching, rarely a little distant, the smallest narrowly oblong, becoming linear, 5 to 30 mm. wide, 12 to 15 mm. in length, the lower small pinnæ very obtuse, the more elongated being rather narrowly obtuse; rachis strong, depressed, lineate, slightly curved or flexuose.

Pinnules small, slightly polymorphous and irregular, alternate or subalternate, rarely subopposite, those in the lower portion of the largest pinnæ or the basal pair in the small pinnæ at a right angle to the rachis, the others more or less oblique, usually touching or even overlapping, more rarely a little distant, laterally unequal, often ovate-round when very small, the lowest pair in the very small pinnæ being often nearly reniform, the succeeding pinnules broadly ovate, narrowly ovate to ovate-oblong, round at the apex, only the lowest pair in the smaller pinnæ, or the lower large pinnules in the large pinnæ, or those a little below the apex of the penultimate pinnæ, constricted to near the midrib, the others being less constricted, especially at the proximal angle, those near the top of the large pinnæ or throughout the greater part of the small pinnæ being attached by more than one-half the width, often nearly the whole width, of the pinnæ, after the type of *Callipteridium*, the terminal being ovate or ovate-oblong in the smaller pinnæ, laterally unequal, sublobate by confluence with the last pinnule on one side, slightly undulate, usually obtuse or rounded at the apex, the terminals of the very large pinnæ being rather more elongated

and less broadly rounded or obtuse; lamina thick, slightly coriaceous, a little concave along the middle, somewhat convex ventrally at the border.

Nervation rather coarse, distinct, regular, usually slightly in relief, more or less flabellate in all except the lowest pinnules or the lower part of the largest ultimate pinnæ; primary nerve but slightly differentiated in the small pinnules, or of moderate strength, vanishing near the middle in those pinnules of intermediate size, or passing three-fourths the length of the largest pinnules, decurrent in the smallest, nearer the distal sinuses of the laterally unequal pinnules; nervilles very oblique, often nearly equally close in all parts of the lamina, a large portion springing directly from the rachis, especially in the proximal half of the pinnule in all but the very large or the lowest pair of pinnules, forking twice at a very narrow angle, one or more of the divisions forking again even in the very small pinnules, usually forking three times, sometimes four, in the largest pinnules, while passing, with slight or sometimes no curvature in the smaller pinnules, obliquely to the margin.

The group of modifications or very nearly related forms which is typified by the fern just described is at once the most predominant, interesting, and complex in the fern flora of the entire Pottsville series. The genus is typically distributed in the lower division of the Pottsville series of the Appalachian trough, and wherever fossil ferns are to be found in that division some form or other of the group is present and constitutes by far the most abundant, if not the exclusive, fern species of the flora. Essentially this type is characteristic of the lower division of the Pottsville, it being especially abundant in the vicinity of the Pocahontas coal in the greatly expanded section of that formation in southwestern Virginia. The distribution of the allied forms, as well as the typical form, will receive special attention in another place.

The typical form, described above, the illustrated specimens of which were collected from the roof of the Pocahontas coal in the Flat Top or Pocahontas coal field of southwestern Virginia and southern West Virginia, is especially distinguished from the related forms of the same group by its broadly attached or Callipteridioid pinnules and the obliquity of its nervation, which is close, regular, coarse, and derived in part from the rachis, the midrib being very poorly defined in the small pinnules. Like the other forms from the basal portion of the Pottsville series, it is essentially a *Neurocallipteris*. This synthetic character of the group of old Neuropterids in the earlier Pottsville is particularly important as indicating the common origin of the genera *Neuropteris*, *Callipteridium*, and *Mixoneura*. Certain other Neuropterids of the type of *N. biformis*, which is a typical *Neuralethopteris*, similarly serve as connecting links between the genera

Neuropteris and *Alethopteris*. The subject of the origin and relations of these genera to *Megalopteris* and other Paleozoic types has been discussed by me in connection with the description of a somewhat composite form from the Des Moines series of Missouri.[1]

The pinnules of the typical *Neuropteris Pocahontas* are, in general, rather broadly ovate when small, and rounded at the top. The form of the terminal pinnules of the younger pinnæ resembles that of the true *N. Smithsii* as originally described and figured from Alabama, but the latter is considerably smaller and less sublobate, besides being rather narrower. The species in hand is in reality readily distinguished from *N. Smithsii* by its generally larger pinnules, which are broadly attached, more ovate, instead of oval or nearly round, when small; by the far less developed median nerves, and especially by the much less curved nervilles, which are oblique, springing in part from the rachis, and which seldom meet the border at a right angle.

Throughout the Appalachian trough the typical *N. Smithsii* has hitherto been found to occur in later beds than the typical *N. Pocahontas*. The former is, in the central and southern Appalachian districts, fairly characteristic of the next higher divisions of the Pottsville series, the Clark and Quinnimont formations, or the Horsepen group.

The *Neuropteris Schlehani* Stur is with little difficulty distinguished by its narrower pinnules, which are constricted at the base, the midrib well developed, the nervation strongly curved and meeting the margin at nearly a right angle. The form described by Stur as *N. Dluhoschi*, which Zeiller regards as inseparable from the preceding species, has much that is suggestive of the largest phase of the *N. Elrodi* of Lesquereux.

Among the several modifications or variations of *N. Pocahontas* found in different regions of the Appalachian trough two fairly well-marked forms are present in the Lykens coal region of the Southern Anthracite field. One of these is so different from the ordinary type as perhaps to entitle it to more than a varietal distinction. But since its shape and mode of development are so similar to the normal type, since its earlier examples are somewhat intermediate, and because it is often difficult to discriminate between small fragments of the latter and material apparently derived from young fronds or apical portions of primary pinnæ of the normal form, it seems most practicable to give it only formal or varietal rank. It may be termed and characterized as follows:

NEUROPTERIS POCAHONTAS var. INÆQUALIS n. var.

Pl. XCLXXXVIII, Fig. 5; Pl. CXC, Fig. 7; Pl. CXCI, Figs. 1–4.

Ultimate pinnæ and pinnules much larger than those of the normal form, often twice as large, somewhat lax, rarely opposite, the pinnules

[1] A new Taeniopteroid fern and its allies: Bull. Geol. Soc. America, Vol. IV, 1893, pp. 119–132, pl. i.

a little more distant, oblique, slightly polymorphous, though generally ovate to oblong-ovate when small, becoming oblong and gradually constricted at the base, the largest attached at the midrib, narrowed a little toward the usually very unequal, obliquely rounded, asymetrical base, the attitude and form a little variable, tapering somewhat in the upper two-thirds, obtusely rounded or rounded at the apex, the terminal often elongate-ovate, often nearly acute, the margins, as in the largest pinnules, more or less distinctly sinuate; lamina thin, very slightly convex ventrally at the border; nervation thin, but very distinct; midrib, when developed, becoming flexuose and vanishing in the upper part of the largest pinnules; secondary nerves a little distant, very oblique, usually forking close to the point of origin, the divisions forking twice or three times in passing to the margin, which, even in the largest pinnules, they meet at varying degrees of obliquity.

This variety presents certain phases which would appear to entitle it to full specific rank, though the presence, at one point or another in the Appalachian trough, of other forms showing every degree of transition or genetic connection renders its specific separation impracticable. It affords a fine illustration of unquestionable modification. Thus, certain of the largest of the pinnules are less obliquely narrowed at the base, more distinctly oblong, and even-margined. Such have in our collections sometimes been confused with *Neuropteris biformis* Lx., and accordingly so recorded in the distribution of that really Alethopteroid and very rare form.[1] The phase whose fragmental (often detached pinnules) representatives have been the subject of this error is somewhat characteristic of the middle portion of the Pottsville series.

Another variation, which can be considered as only varietally or perhaps formally distinct from the one in hand, is seen in the plants from the Dade mines in northwestern Georgia, described and illustrated as secondary types of *Neuropteris Smithsii*.[2] While the Dade plants show an outline and habit hardly distinguishable from the variety in hand, they reveal a rather coarser nervation, which is more open near the midrib, often slightly flexuose, and usually a little more distant. A comparison of the types, or even of figs. 1 and 2, pl. xiii, of the Coal Flora, the originals of *N. Smithsii*, with the illustration of the Dade specimen, pl. xcvi, fig. 3, of the same work shows at a glance the specified differences in the fossils. The true *N. Smithsii* has small pinnules open at a right angle, quite constricted at the base, well

[1] The latter, as seen in examples from Alabama, some of which were identified by Professor Lesquereux, have long, tapering pinnules, thick, persistent midribs, strongly arched close nervation, the terminal and preceding pinnules being almost typically Alethopteroid. These features, slightly imperfectly shown in the Coal Flora (p. 121, pl. xiii, fig. 7) will later be more fully illustrated from typical material.

[2] Lesquereux, Coal Flora, Vol. III, p. 734, pl. xcvi, figs. 3, 3a. No. 1156 Lacoe Collection, United States National Museum.

developed midribs even in the small pinnules, with very open nervation originating from the midrib. It is, moreover, a much smaller species.

Many of the larger pinnules, with strongly oblique, unequal bases, are possibly suggestive of the *Neuropteris antecedens* of Stur, from the Hainichen-Ebersdorf beds. The very strong resemblance of specimens from the Kalmia mine to *Cardiopteris eriana* Dawson[1] is worthy of note, as is also the association of the latter with the *Odontopteris squamosa* Dn.,[2] which deserves a special comparison with the *Neuropteris Pocahontas* group of Pottsville forms.

Neuropteris Pocahontas var. pentias n. var.

Pl. CLXXXVIII, Figs. 2, 3, 3a, 4; Pl. CLXXXIX, Figs. 5, 5a, 5b.

The other Lykens form of *Neuropteris Pocahontas*, to which reference has been made above, is, so far as I have observed, nearly everywhere slightly older than the one above mentioned, its habitat in the southern field being essentially in the lowest of the Lykens beds, coals Nos. 5 and 6. It may be distinguished from the normal type and other forms as follows:

Pinnules smaller than the normal type, very broadly attached, hardly so crowded, more distinctly triangular, laterally unequal, oblique, the terminals as well as the largest pinnules more elongate, often sinuate-margined, narrower and more acute, the proximal basal pinnule situated in the angle of the pinna, the nerves regular, more slender, rather closer, often less oblique at the border, the lamina being thick and faintly irregularly striated between the nervilles, very many of which, in all but the large pinnules, spring directly from the rachis.

Occasionally the younger pinnules of this variety assume a distinctly and rather broadly triangular form, while the pinnæ are much more slender and acute, the narrow terminal being not infrequently sinuate-margined. The nervation of this form is fairly distinct, though thin, the nerves close, regular, and in the larger pinnules often nearly at a right angle to the border, although occasionally they turn upward slightly just before reaching the margin. The surface of the rather thick pinnules is often shiny, though when viewed under the lens it is seen to be irregularly striate as though impressed by minute scaly hairs nearly parallel to the nervation, as indicated in Pl. CLXXXIX, Fig. 5b. The terminal pinnules of the larger pinnæ are slender and acute, those of the smaller lateral pinnæ being proportionately long.

This, the more apiculate variety of *Neuropteris Pocahontas*, is not likely to be confused with any of the other forms or varieties of the species, on account of the form and attachment of the pinnules and the nervation. *N. Smithsii*, which at times it somewhat resembles, differs, among many characters, by its basally constricted, short pin-

[1] Foss. Pl. Erian, Pt. II, 1882, p. 114, fig. 4. [2] Op. cit., p. 114, fig. 2.

nules, the obtuse, short terminals, the distinct midrib, and the open, slightly flexuous nervation.

The normal form of *Neuropteris Pocahontas* is not so abundant in the Lower Lykens division of the Southern Anthracite field as in the vicinity of the Pocahontas coal in the Southern Appalachian region. It is, however, found at the Brookside mines, at Kalmia, at Williamstown, at the Swatara Gap, and in the gap at Pottsville. The variety *inaequalis*, though often difficult to distinguish from the normal form in small fragments, is more readily discernible in specimens from the roof of the Lykens coal No. 4, where it occurs at the Brookside mines, at the Lincoln mine, at Kalmia, at the upper Eureka drift, at Rausch Gap, at the shaft 160 yards northeast of the North Brookside slope, at the Swatara Gap, and at the Pottsville Gap. The variety *pentias* is, as has several times been remarked, confined, so far as is known, to the roof shale of Lykens coal No. 5, or to lower horizons. Typically, at least, it does not seem to occur so high as Lykens coal No. 4. Specimens of this variety are present in the collections from the Lincoln colliery, from the Brookside mines, from the Kalmia colliery, from the west side of Rausch Gap, Schuylkill County, and from a low bed in the Pottsville Gap.

Neuropteris Smithsii Lx.

The typical form of this species, first described by Professor Lesquereux from the Warrior coal field in Alabama, is illustrated in pl. xiii, figs. 1, 2, 3, and 3ª of the atlas to the first volume of the Coal Flora, page 106. The original or true form is characterized by the very small oval pinnules, which are completely constricted at the base; by the development of a distinct though not strong midrib; and by the open angle of origin of the nervilles, which pass slightly irregular to the margin, meeting the latter nearly at a right angle. The terminal pinnules are always short, obtusely rounded, and inequilateral. This form, which is common in the upper part of the Clark formation in West Virginia, and which appears to be represented by a slight modification in the horizon of Lykens coal No. 4 in the Southern Anthracite field, is quite distinct from the plant of Callipteridioid habit, with broadly attached pinnules, and flabellate, oblique nervation, from the Dade coal in Georgia, figured in the third volume of the Coal Flora under the above name.

Neuropteris Smithsii is without difficulty distinguished from *Neuropteris Pocahontas* by essentially the same differences as those indicated above in speaking of the Dade fern. The pinnules of the variety *pentias*, while often of the same size as those of *N. Smithsii*, are conspicuous for their broad attachment, trianguloid form, and Odontopteroid nerves, while the terminals are elongated and more acute. *Neuropteris Elrodi*, which is characteristic of the Sewanee zone of the Pottsville formation, is distinguished from *Neuropteris Smithsii* by its

triangular, more unequal, inflated pinnules, with persistent midribs, and more open, strongly backward-curved nervation. *Neuropteris Smithsii* has been collected at the Brookside and Lincoln mines; at Kalmia, the upper Eureka tunnel, the Broad Mountain mines, and the Lower Lykens division in the Pottsville Gap.

Neuropteris Elrodi Lx.

The plants from the Southern Anthracite field identified under this name agree with the original specimens described and figured by Lesquereux[1] as having been derived from the Montevallo coal in Alabama. The character of the matrix is, however, very distinct from that of other material in the collection from that locality, it being in very close agreement with specimens from the Whetstone beds of Indiana, in which this species is also said to have been found. I suspect that the types originated in the Whetstone beds. The originals represent a species quite different from that in the roof of the Sewanee coal in Tennessee, later figured[2] by Lesquereux under the same name. The latter is, perhaps, inseparable from *Neuropteris Schlehani* Stur. The differences between this species and *Neuropteris Smithsii*, the only species in the Pottsville flora with which *Neuropteris Elrodi* is liable to be confused, have been noted in the remarks on the former. *N. Smithsii*, it will be remembered, is characteristic of the *Mariopteris pottsvillea* zone in the Lower Lykens division, while *Neuropteris Elrodi* is almost exclusively confined to the Sewanee zone of the Upper Lykens division, though in its typical form it is not common at so low a horizon as that of the Sewell-Sewanee coal.

The fern has been found in the horizon of Lykens coal No. 2, at the Lincoln mines, at the North Brookside slope, and in beds at approximately the same horizon in the Pottsville and Westwood gaps.

Neuropteris Aldrichi (Lx.).

This species, which was described by Lesquereux[3] as *Callipteridium Aldrichi*, from the Black Creek coal at the Jefferson mines in Alabama, represents a peculiar form, rather closely related to *Neuropteris Smithsii* and *Neuropteris Elrodi*, although sometimes suggesting *Oligocarpia* or *Pecopteris* in the form of its pinnæ and pinnules. It constitutes one of the singular composite types in the Pottsville formation, and it will be described and further illustrated in connection with the monographic treatment of the flora of the Pottsville formation in the Appalachian province.

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[1] Coal Flora, Vol. I, p. 107; Atlas, p. 3, pl. xiii, fig. 4.
[2] Ibid., Vol. III, p. 735, pl. xcvi, figs. 1, 2.
[3] Ibid., Atlas, p. 7, pl. xxxviii, figs. 1, 1a, 1b, 2, 3; text, Vol. I (1880), p. 171.

Neuropteris tennesseeana Lx. MSS.

The fragments representing this species, from a bed about 550 feet below the Twin coal in the gap at Pottsville, appear to agree in all respects with the types described in manuscript by Professor Lesquereux as *Neuropteris tennesseeana*. This species, which seems to have been derived from the original *Neuropteris Pocahontas* stock, and which has many features in common with *Neuropteris heterophylla*, appears to be characteristic of the lower portion of the Sewanee zone, in both the Walden formation in Tennessee and the Upper Lykens division in the Southern Anthracite field.

Neuropteris ovata Hoffm.

The normal form of this species, which elsewhere is not known at so low a horizon as the uppermost beds of the Pottsville formation, appears to be present in the Southern Anthracite field in one of the shale partings in the topmost group of conglomerates, at 245 feet below the Twin coal. The variety *antiqua*, which is characterized by slender, apiculate pinnules, very broadly attached to the rachis, and by the unusually oblique nervation, is present in material from the rock dumps at the Lincoln collieries, although I am not certain to which of the Upper Lykens coals the fragments should be referred.

Neuropteris gigantea Sternb.

Under this name I provisionally refer the material described by Professor Lesquereux[1] as *Neuropteris subfalcata*. The original form, as described and figured by Sternberg, if present in our Carboniferous basins, appears, so far as yet known, to occur only in the topmost beds of the Pottsville formation. Most of these specimens from the roof shales of Lykens coal No. 2, or from the higher horizons of the Sewanee zone, are generally more elongated than the Old World type. The examples from the Kemble drift appear to represent a new variety, *elavata*, the most salient or distinctive features of which are the generally greatly elongated, though somewhat polymorphous, pinnules, which are frequently broader in the upper third than in any other portion of their length; the extremely slender and poorly defined median nerve; and the very oblique, close, hair-like, parallel nervation, a portion of which springs directly from the rachis.

Neuropteris lunata sp. nov.

Pl. CXCIII, Figs. 3–7.

Frond and mode of development of the pinnæ probably similar to those of *Neuropteris gigantea*, the rachis attaining a width of 12 mm. or more, very distantly but coarsely punctate, the penultimate rachis being

[1] Coal Flora, Atlas, p. 3, pl. xiii, figs. 5, 6; text, Vol. I (1880), p. 102.

provided, between the ultimate pinnæ, with polymorphous broad, short pinnules.

Pinnules of the ultimate pinnæ linear-, or slightly triangular-linear-subfalcate, usually short, four to six times as long as broad, with narrow cordate or slightly squarrose base, tapering upward toward the obtuse or obtusely acute apex, and usually turned upward with a uniform curve throughout the whole length, though often nearly straight; the rachial pinnules triangular, triangular-ovate, cordate, or even cordo-reniform, and very small; lamina a little thick, depressed in a narrow, rather shallow furrow along the median line, slightly convex ventrally, especially at the margin.

Nervation sharply distinct, ventrally depressed, dorsally in relief; median nerve not very strong, but distinct and traceable to very near the apex; nervilles originating at a moderately open angle, a little distant, forking at a slightly open angle near the base, and similarly once or twice again, according to the size of the pinnule, in curving toward the margin, which they meet obliquely, except in the lower part of the pinnule, counting about 30 to 38 per centimeter.

Although the pinnules of this species occur in great abundance on the surface of the shales, no large segments of pinnæ have been found. Nevertheless, the presence of the small and somewhat polymorphous pinnules, corresponding to those from the rachis in the preceding species, as well as the phases and similar characters of the large pinnules, strongly indicates a development of the pinnæ in the same general manner as in *Neuropteris gigantea*, to which it is undoubtedly closely related.

The most noticeable features of the pinnules are their slenderness, the crescentic curvature, the squarrose-cordate base, the distinct midrib, and the slightly distant nerves, which fork a little widely, although the divisions may at once assume a nearly parallel direction.

The pinnules of *N. lunata* are more slender than those of *N. gigantea*, and proportionately less acute, the curvature, when present, being generally more uniformly distributed, slightly crescentic, through the whole length instead of being expressed as an upward turn near the apex. Often, however, they are but slightly curved or nearly straight. The midrib is much stronger and more persistent even than in *N. Zeilleri* Pot.,[1] it being clearly traceable, though thin, very nearly to the apex. The angle of division of the nerves, as noted above, appears greater than in the last species, and is certainly much greater, while the nerves are less oblique, than in *N. gigantea* var. *elavata*. Some of the small roundish rachial pinnules seem, when detached, to be not separable from similar small basal pinnules in some other species of *Neuropteris*. But the average pinnules may be

[1] Jahrb. d. k. Pr. Geol. Landesanst u. Bergakad., Vol. XII, p. 22, pls. ii-iv, text fig. 1–4.

easily differentiated by their form and nervation from any other species with which I am familiar. Occasionally a small narrow pinnule, such as that in Fig. 7, suggests, particularly in its nervation, pinnules of *N. rarinervis*. Even these may be separated by recalling the dilated and distinctly cordate bases and the slightly concave lateral margins of the latter.

This species is abundant in the roof shales over Lykens coal No. 1 at the Lincoln mines.

Asterophyllites parvulus Dn.

The specimens from the Southern Anthracite field which I refer to this species appear to be in complete agreement both with the plant originally described under the above name from the supposed middle Devonian beds at St. John,[1] New Brunswick, and with the material from Rushville, Ohio, described by Andrews[2] as *Asterophyllites? minutus*.

Subsequent stratigraphic and paleontologic study of the deposit of dark leathery shales at Rushville shows them to be probably not far from the horizon of the Sharon coal in Ohio. Many of the examples of the *Asterophyllites* from the Southern field are even smaller than those figured by Sir William Dawson and Professor Andrews. This species, perhaps the smallest of its genus, is closely related to *Asterophyllites arkansanus* and *A. grandis*. Although to a certain extent characteristic of the Sewanee zone throughout the central Appalachain region, the *Asterophyllites parvulus* is not only common in the same zone of the anthracite region, but it is often abundant in the roof shales of Lykens coal No. 4, in which horizon it is found at the Brookside and Lincoln mines.

Asterophyllites arkansanus nom. nov.

The species to which I give the name *Asterophyllites arkansanus* is that known in the American literature as *Asterophyllites gracilis*, a name which, unfortunately, must be abandoned, the *A. gracilis* (Sternb.) Brongn. having priority. As originally described[3] by Lesquereux, from the coal-bearing shales of Arkansas, the species is especially characterized by the thick axes of the branchlets, the angularity and dilation of the internodes, and the strongly reflexed, outward-curved, slightly angular, and rapidly tapering, small, acute leaves. The plant is found associated with the Upper Lykens coals at the Lincoln mines and at the supposed approximate horizon of Lykens coal No. 3 in the gap at Pottsville.

[1] Dawson, Acadian Geology, 1868, p. 540, fig. 188 A[a–c]; Fossil Plants of the Devonian and Upper Silurian Formations of Canada, 1871, p. 27.

[2] Rept. Geol. Survey Ohio, 1875, Vol. II, Pt. II, p. 424, pl. li, figs. 4, 4[a].

[3] Rept. Geol. Surv. Arkansas, Vol. II, 1860, p. 310, pl. ii, figs. 4 and 4[a].

Annularia acicularis (Dn.) Ren.

This species, which is, perhaps, most closely related to *Annularia radiata* Brongn., and which was described by Dawson from the fern ledges (Lancaster formation) at St. John, New Brunswick, as *Asterophyllites acicularis*, is not rare in the Sewanee zone of the Pottsville formation, its most frequent occurrence being in the upper part of that zone. Its salient features are the slender axis and the very slender leaves, which are distinctly narrowed, in tapering form, both toward the base and toward the apex. It has been very well illustrated in the publications of Sir William Dawson.[1] The plant occurs in the Sewanee zone at the Lincoln mine and in the Pottsville Gap.

Annularia cuspidata Lx.

The typical form of this species, as illustrated by Lesquereux,[2] from the dark shales at Rushville, Ohio, has a rather wide geographic distribution throughout the Appalachian region, in the uppermost part of the Sewanee zone, or in the zone of Lykens coal No. 1, it being one of the characteristic forms of that portion of the sections. In the Southern Anthracite field it occurs in the roof of Lykens coal No. 1 at the Lincoln mine, and in the plant beds 380 feet below the Twin coal in the Pottsville Gap.

Annularia latifolia (Dn.) Kidst.

A comparison of the material in hand with specimens from the middle Devonian at St. John[3] unquestionably shows the specific identity of the American material with that from New Brunswick. It is, perhaps, specifically indistinguishable from the leaf verticils from Campbell Ledge described by Lesquereux[4] as *Calamites ramifer* Stur. In the Pottsville formation this species, which appears to stand in an ancestral relation to *Annularia stellata*, occurs near the horizon of the Lykens coal No. 1—i. e., near the base of the Fayette formation in the Virginia region and in bed L, 380 feet below the Twin coal, in the Pottsville Gap.

Sphenophyllum tenerrimum Ett. var. elongatum n. var.

Pl. CXCIII, Figs. 8, 9.

This variety differs from the species as described by Ettingshausen[5] chiefly by the considerably larger size of the verticils and the more

[1] Quart. Jour. Geol. Soc. Lond., Vol. XVIII, 1862, p. 310, pl. xiii, fig. 16a 16b; Acadian Geol., 1868, p. 555, fig. 194 II[1]; Fossil Plants of the Devonian and Upper Silurian Formations of Canada, 1871, p. 28, Pl. V, figs. 51a-c, 57.

[2] Coal Flora, Vol. III, p. 725, pl. xcii, fig. 7, 7a.

[3] Dawson, Quart. Jour. Geol. Soc. Lond., Vol. XVIII, p. 311, pl. xiii, fig. 17a-c; Acadian Geol., 1868, p. 538, fig. 187 A and D'; Geol. Hist. Plants, 1888, pp. 78, 265, fig. 28a, D., D[1].

[4] Coal Flora, Vol. III, p. 703, pl. xci, figs. 4 and 4a.

[5] Helmhacker, Beitr. Kenntn. Südrandes Oberschl. Pol. Steinkohlenf., p. 28, pl. iii, figs. 5–16; Stur Culm.-Flora, Pt. II, p. 108, pl. vii, text figs. 21a-c, p. 110; 22, p. 111; 23 A-F, p. 114; 24, p. 115.

frequent dichotomy. The proportions of the variety are very nearly those of the form described by Stur[1] from the Schatzlar series. The plant in hand differs from *Sphenophyllum bifurcatum* by its more slender stems, by its more delicate, narrower, more rigid, and deeply dissected leaves, and by the linear, obtuse form of the lobes. *S. bifurcatum* is more nearly connected by its variable leaf, which is often much less divided, to the *S. cuneifolium* group than is the above-named variety, all of whose leaves are of the more linear, entirely dissected, delicate type. In the Southern Anthracite field this variety appears to be one of the plants characteristic of the horizon of the roof shales of Lykens coal No. 2, where it is almost invariably associated with *Neuropteris Elrodi*, *Mariopteris pygmæa*, and a small species of *Eremopteris*. It is especially common in this horizon at the Lincoln mines.

Sphenophyllum bifurcatum Lx.

This species, as originally described by Lesquereux, from beds now known to lie within the Sewanee zone of the Pottsville formation in Arkansas, appears, as has already been suggested, to be intermediate between *Sphenophyllum tenerrimum* and *S. cuneifolium*. The less-divided leaves of the Arkansas plant might easily be mistaken in some cases for the latter species. It differs, however, in the position of the leaves and their aspect in the verticils, in the wider form of the leaf, and in the more distant and generally more rigid teeth. The distinctions between *Sphenophyllum bifurcatum* and *S. tenerrimum* have already been indicated. The former is not infrequent in the upper part of the Sewanee zone; more rarely it is found in the lower part of the same zone. In the Southern Anthracite field it is found over the coal mined at Kohlers Gap; at the horizon of the roof of Lykens coal No. 2, at the North Brookside slope; and in the Pottsville Gap at the approximate level of Lykens coal No. 3. A form of doubtful specific identity occurs at a level supposed to be not far above that of the roof of Lykens coal No. 4 at the Kemble drift on Broad Mountain.

Sphenophyllum cuneifolium (Sternb.) Zeill.

As has already been noted in the discussion of the floras in the several horizons of the Pottsville formation, two forms which appear to be referable to this species occur in this formation. The first, which is represented by the type figured by Lesquereux in fig. 9, pl. xciii, Vol. III, of the Coal Flora, is especially characterized by its slender, narrow, lax form, thin, rather membranous texture, equal teeth, and slender, fine nervation, the forking of which occurs mostly in the lower part of the leaf. The second form may be briefly described as more closely resembling the smaller, narrower, and often dissected leaves

[1] Die Calamarien d. Schatzlarer Schichten. 1887, p. 202, pl. xv, figs. 1a, 1b, 4.

of *Sphenophyllum emarginatum*. It exhibits the more rigid type of leaf, with the coarse nervation of the latter, to which the Pottsville form appears to stand in an antecedent relation. The leaves of the first type, which is more typical of the horizon of the Sewell-Sewanee coal, or Lykens coals Nos. 2 and 3, in the Southern Anthracite field, are relatively rarely dissected, while those of the second or more rigid type, which occurs in the Upper Intermediate division in the anthracite region, are nearly always unevenly dissected.

Sphenophyllum tenue sp. nov.

Pl. CXCI, Figs. 6, 7.

Stems slender, distinctly though not very prominently ribbed, carinate, 1 to 3 mm. in diameter, branching a little freely, the branches, often in verticils of three, springing from within the bases of verticils of very deeply dissected leaves; nodes distinct, 1 to 5 cm. distant, usually having the leaves still attached; leaves in verticils of six, oblique at the base, very rapidly spread in nearly equidistant radiation, broadly cuneate, 1 to 2 cm. in length, usually about 8 mm. in width, very thin or membranous, lax, the apices round-truncate, more rounded near the angles, sometimes with a faint sinus at the center, crenulo-denticulate in 12 to 24 short, broad, round-obtuse teeth, or rarely more or less dissected in broad, very lax, obtuse, usually bi or tri dentate laminæ, the lateral margins distinctly, sometimes rather strongly, concave and converging downward in a slender, very narrow, relatively long, slightly thickened base; primary nerve single and rather strong for some distance in the lower part of the leaf, forking four or five times at a slightly narrow angle in passing upward, slender and delicate, to furnish one nerville for each tooth or denticulate crenulation.

The salient features of this species are the large, membranous, very broadly cuneate, crenulate-denticulate, slightly rounded leaves, with distinctly if not conspicuously concave lateral margins and long slender bases, in verticils of six, on very slender stems. The aspect of the somewhat rounded, rarely sinused apex, the transparent lamina, and the narrow, slender bases, below such broad apices, make the plant easily recognizable among the other species of its genus. The nervation is thin and delicate, derived by numerous bifurcations from a rather thick, single, primary bundle that passes for some distance through the narrow base of the leaf before dividing. Leaves of the dissected type, such as that shown in Pl. CXCI, Fig. 7, are more rare. Although they bear a closer resemblance to the laciniate forms of other large-leafed species, they are easily distinguished by the irregular, very broad, obtuse, and lax type of the lacineæ, which show a markedly broad spread at the top, and by the concave lateral profile and the

slender, almost stalk-like base, as in the normal form. The leaves at the base of the branch verticil are much more elongated and deeply and narrowly cut than in the normal type.

Sphenophyllum tenue appears to be related to the *S. majus* of Bronn, though the differences noted above seem to readily distinguish it from that as well as other species. It is also closely allied to another very large-leafed species, not yet described, from the Vespertine or Pocono series (basal Carboniferous) of southwestern Virginia, between which and the former it appears to be intermediate.

The species here described is one of the most beautiful as well as widely distributed plants of the Pottsville series, ranging in identical forms along the Appalachian trough from Pennsylvania southward to Warrior, Alabama. In general it is quite characteristic of the middle or Horsepen division (Clark formation) of the Pottsville series, to which its horizon in the roof of Lykens coal No. 4 also belongs. Although several fragments from near coal No. 2 or No. 3 at the New Lincoln mine appear so nearly in agreement with the types as to be not readily distinguishable from the typical form, I have not met it elsewhere in the Upper Lykens division or the Sewanee zone. It is not certain that the specimen is from the Upper Lykens division. In the Southern Anthracite field the species occurs in the roof shales of Lykens coal No. 4, at the Brookside and Lincoln collieries, the Kemble drift, the North Brookside prospect shaft, and in the gap at Pottsville.

Lepidodendron alabamense sp. nov.

The species which will later be described in full and illustrated under the above name includes the specimens from the upper part of the Clark and from the Quinnimont formations in the Virginia region, and from the vicinity of the Warrior coal in the Alabama section, included by Lesquereux[1] in *Lepidodendron Sternbergii*. It belongs to a Lepidodendroid type presenting several phases or modifications in the different zones of the formation. Typically, however, as seen in the region of Lykens coal No. 4, or in the Quinnimont formation, in which it is generally found in association with *Mariopteris pottsvillea*, *Neuropteris Smithsii*, *Sphenophyllum tenue*, *Lepidophyllum quinnimontanum*, and *Trigonocarpum Helenæ*, it is especially characterized by the robust, thick branchlets, densely clothed with thick, rigid, rather short leaves, which, though very oblique at the bases, rapidly curve outward, upward, and then inward, while tapering gradually, so that their upper portions assume a distinctly incurved or somewhat uncinate form. Stems and branches of this type are present in the roof shales of Lykens coal No. 4 at the Brookside mines and at Kalmia, and in the Pottsville Gap at a horizon about 775 feet below the Twin coal.

[1] Coal Flora, Vol. II, p. 366.

Lepidodendron clypeatum Lx.

To this species, which has been well illustrated by Professor Lesquereux,[1] I refer most of the specimens from the Sewanee zone in Arkansas and Alabama labeled in our collections as *Lepidodendron Veltheimianum* Sternb. Some of its phases are only with difficulty distinguished from the type described by Sternberg as *Lepidodendron Rhodeanum*,[2] which, in turn, appears to be closely related to and often confused with *Lepidodendron obovatum* of Sternberg. The forms I refer to *Lepidodendron clypeatum* have a wide distribution in the Pottsville formation in the Southern Anthracite field, their range being from the horizon of the roof shales of Lykens coal No. 4, or possibly No. 5, to the level of Lykens coals Nos. 2 and 3, from which the specimens are specially abundant as well as typical.

Lepidophyllum quinnimontanum sp. nov.

This species of *Lepidophyllum* constitutes one of the characteristic types of the *Mariopteris pottsvillea* zone throughout the Appalachian region, although it rarely occurs in the horizons of the roof shales of either the Pocahontas coal or the Lykens coal No. 5. The collections from the Southern Anthracite field contain one or two specimens which may possibly have come from the shales of Lykens coals Nos. 2 and 3. The species is especially characterized by the linear-lanceolate form of the bracts, which are 5.5 to 8 cm. long and 10 to 13 mm. wide at the widest point—some distance above the middle. The sporangiophores are cuneate and proportionately long, their length being usually over one-fourth that of the blade, which is dilated and auriculate at the base, slightly contracted just above, and which tapers with slightly convex borders from its widest point, above the middle, to an unusually narrow acuminate apex. The midrib is broad and strong throughout, while the lamina is obscurely lineate longitudinally, the lines slightly diverging toward the margin. The most important differentiative features are the relative length of the base, the dilation in the upper part of the blade, and the acute apex. The bracts are much larger and generally longer than those of *Lepidophyllum campbellianum*,[3] the sporangiophores of which are short, small, and generally rather broadly cuneate. So far as the distribution of these two species has yet been observed in the Pottsville formation, it appears that *L. campbellianum* is characteristic of the Sewanee zone and the Upper Intermediate division, while *L. quinnimontanum* is, in general, almost exclusively confined to the Lower Lykens division. The latter species is present in the roof shales of the Lykens coal No. 5 at the

[1] Geol. Pennsylvania, Vol. II, Pt. II, p. 875, pl. xv, fig. 5, pl. xvi, fig. 7. Coal Flora, Atlas, p. 12, pl. lxiv, figs. 16 16a (not figs. 17, 18).

[2] See Stur, Culm-Flora, Pt. II, p. 283, pl. xxiii, fig. 1; pl. xxiv, fig. 1-3.

[3] Lesquereux, Coal Flora, Vol. III, p. 786, pl. cvii, figs. 6, 7.

Lincoln colliery, though its frequent occurrence at other localities is at or near the horizon of Lykens coal No. 4.

Bothrodendron arborescens (Lx).

The examination of the stem fragments in the types described by Lesquereux as *Lycopodites arborescens*[1] reveals leaf scars showing the typical characters of the genus *Bothrodendron*. The collections in hand from the lower portion of the Kanawha series in West Virginia show that this genus is not rare at that stage in the Coal Measures in the United States. *Bothrodendron arborescens*, the originals of which are from the Sewanee zone in Washington County, Arkansas, while the Pennsylvania representatives occur in the plant beds 380 feet below the Twin coal in the Pottsville Gap, appears to constitute the oldest representative of the genus yet discovered on this continent.

Cordaites Robbii Dn.

The identity of the leaves from the Pottsville formation with the species described by Dawson[2] from the fern ledges at St. John, New Brunswick, seems to be fully assured by a comparison of material from the type locality. The species appears to be especially common in the Upper Lykens division of the formation, although it has a wider vertical range. It is quite possible that the form which will eventually be described as *Cordaites Phillipsi* is not more than varietally distinct from the St. John type. In the Southern Anthracite field the species occurs, as at St. John, in association with *Cardiocarpon cornutum*. It is found at the supposed horizon of Lykens coals 2 or 3, about 550 feet below the Twin coal, in the Pottsville Gap, in the shales accompanying the upper Lykens coals at the Lincoln mines, in the Lower Lykens division at the Brookside mines, and in the Lincoln mine. It is also found accompanying the upper Lykens coal in Yellow Springs Gap.

Cordaites angustifolius Dn.

The material which I refer to this species appears to be in agreement with the species figured by Sir William Dawson from the fern ledges at St. John,[3] rather than with the material earlier described[4] from the Devonian at Gaspé. If the Gaspé fossils are specifically different from those at St. John, as appears to be the case from an inspection of the figures, the name should be retained for the Gaspé

[1] Coal Flora, Vol. III, p. 778, pl. cvi, fig. 1. Lacoe collection, United States National Museum, Nos. 5559, 5560, and 5567.

[2] Quart. Jour. Geol. Soc. Lond., Vol. XVIII, p. 316, pl. xiv, fig. 31a-c; Acadian Geol., 1868, pp. 534 and 541, fig. 190; Fossil Plants of the Devonian and Upper Silurian Formations of Canada, 1871, p. 13, pl. xiv, figs. 156–162, 156a.

[3] Quart. Jour. Geol. Soc. Lond., Vol. XVIII, p. 318; Fossil Plants of the Devonian and Upper Silurian Formations of Canada, 1871, p. 41, pl. xiv., fig. 163a-e.

[4] Canadian Naturalist, Vol. VI, pp. 170 and 176, fig. 11c; Logan, Geol. Canada, 1863, p. 399, fig. 428.

types. From an examination of examples from St. John, I am disposed to regard the latter as possibly young leaves of *Cordaites Robbii*, to which they are undoubtedly at least very closely related. In the anthracite field, as at St. John, both species occur in the same beds.

Cordaites grandifolius Lx.

The most conspicuous features of this interesting species are the great breadth and broadly cuneate form of its large leaves. The base is narrow, the lateral margins always more or less strongly concave, and the distal margin, or top, rounded or round-truncate, and cut, in the older examples, into short, broad, unequal, round-truncate lobes. In fact, the general form, texture, nervation, and the mode of lobation at the apex are suggestive of the Ginkgoales. This species appears to be present in the material from the west side of Kohlers Gap in Bear Mountain, and from the rock dump from one of the upper Lykens coals at the New Lincoln mine. The originals described by Lesquereux[1] are from Campbell Ledge, near Pittston, Pennsylvania.

Whittleseya elegans Newb. var. minor n. var.

The interesting type of vegetation described by Dr. Newberry[2] from the roof of the Sharon coal at Tallmadge, Ohio, as *Whittleseya elegans*, has been discovered at a number of other points in the Sewanee zone, throughout the Appalachian province. At various localities and horizons a number of additional species or varieties have also come to light. The leaves of the variety *minor* are much smaller than those of the normal form, and are proportionately broader, they being usually a little broader than long. The nerve fascicles are also a little more crowded, numbering about fifteen to the centimeter at the top. The form, texture, and nervation of this species, which can hardly be else than a gymnosperm, are such as to appear to justify its reference to the Ginkgoales. The variety was obtained from the parting between Lykens coals Nos. 2 and 3 at the Lincoln mine.

Whittleseya microphylla Lx.

The salient features of this species, described by Lesquereux,[3] are the small size, the distinctly cuneate form, and the fasciculately fibrous texture of the leaves, which range from 5 to 15 mm. in length and average about 6 mm. in width. The fasciculate nerve bundles, which, as in *W. elegans*, are in part derived from the thickened lateral margin in the base of the leaf, constitute rather poorly defined longitudinal ribs, each of which enters a usually obscure, rounded tooth in the

[1] Proc. Am. Philos. Soc., Vol. XVII, 1878, p. 318, pl. xlviii, figs. 1, 2, 2a. Coal Flora, Atlas, p. 16, pl. lxxvii, figs. 1, 2, 2a; text, Vol. I, p. 530.

[2] Annals Sci., Cleveland, Vol. I, 1858, p. 116, figs. 1, 2a–b. Lesquereux, Coal Flora, Atlas, p. 2, pl. iv, figs. 1 1a. Renault, Cours. bot. foss., Vol. IV, p. 69, pl. v, figs. 9 and 10.

[3] Coal Flora, Vol. III, p. 843.

distal margin. The latter appears slightly crenulate. The distinctly cuneate form and small size of this species, which is intermediate to the broad *W. elegans* on the one hand and the lineate *W. Campbelli* on the other, readily separate the leaf from those of other species in the genus. From a stratigraphic standpoint this type appears to be one of the most important, since it seems almost exclusively confined to a small vertical range above the level of the Sewanee coal.

The representatives of this species in the anthracite field are from the roof of Lykens coals 2 or 3 at the New Lincoln colliery.

Whittleseya Campbelli sp. nov.

Pl. CXC, Figs. 9, 10, 11.

Leaves very small, linear or slightly oblong-linear, 12 to 22 mm. long, 2.25 to 5 mm. wide, generally 12 to 15 mm. long and 2.5 to 2.75 mm. wide, often very slightly cuneate, straight or slightly arched laterally, acuminate at the rapidly contracted base, the lateral borders nearly parallel from a point less than one-fourth of the way from the base upward to very near the truncate, acutely though very obscurely denticulate apex, where they normally converge somewhat, the outer teeth being inclined inward and usually crowded against or overlapping the interior teeth; texture densely fibrous, thick, more or less distinctly rounded-ribbed by 3 to 5 longitudinal, parallel, finely lineate ridges produced by the very thick contiguous fascicles of nerves, each of the dense, broad fascicles entering a tooth; petiole filamentoid, lax, very faintly striate, blending with the slightly thickened margins of the acuminate base of the leaf; nervation distinct, dividing at or near the base in 3 to 5 or 6 close, greatly thickened fascicles, giving the leaf a parallel-ribbed and striated surface, the nerves of each fascicle being slightly connivent in one of the apical teeth of the leaf.

The species described above is one of the most widely distributed plants in the Pottsville series, in which it ranges horizontally from northern Ohio and northeastern Pennsylvania to the overlap of the Cretaceous in Alabama, and vertically from near the base of the Pottsville to the base of the main upper plexus of conglomerates. So far as is yet known, this species was the earliest of the representatives of its genus to appear, it being found, in the deepest section of the Appalachian Basin, nearly 1,000 feet below the levels of *Whittleseya elegans* or *W. microphylla*, and several hundred feet lower than any of the other closely related, more or less linear forms.

In general it presents a great uniformity in its features, there being no marked variation in either form or size among the abundant examples which are to be found at nearly every locality. Some modifications are, however, to be seen in the course of its vertical range, as well as in its local development. Thus the oldest observed forms were

prevailingly small, not over 13 mm. long, and narrow, though the species soon assumed its normal proportions in the Clark and Quinnimont divisions of the Pottsville in the central Appalachian region, and near the horizons of the Lykens coal No 4 and the lower Lykens coals of the Southern Anthracite field. Occasionally larger or longer leaves occur locally in the Lower Lykens division; but in the Sewanee-Sewell zone, or Upper Lykens division, a larger form is somewhat characteristic, while in the upper part of the series, at certain points in the Southern States, and in the roof of Lykens coal No. 2, a very much elongated slender form is found to prevail, almost if not quite exclusively, locally. It is also possible that the large, arcuate leaves which occur near Birmingham, Alabama, and at the Kemble drift and Kohlers Gap, are hardly specifically separable from the species in hand, notwithstanding their local abundance and exclusiveness.

The characters of the bases and petioles of these leaves are shown in Pl. CXC, Fig. 9. Typical examples are illustrated from the Lykens coal No. 5 in Pl. CXC, Figs. 10 and 11. The specimen seen in Fig. 10 is below the average in size. As will be observed on an inspection of the drawings, the mode of origin of the nerve fascicles, the slightly ribbed character of the leaf, its dense fibrous texture, the teeth, in which the nerves of each fascicle appear to be somewhat connivent, and the nature of the petiole, all indicate its common generic relation to *Whittleseya microphylla* and *W. elegans*. Owing to the thickness and inward inclination of the teeth, the latter are often obscured by imbrication or superposition. Not infrequently, however, they are spread out erect, when the clearness of the dentation, the vascular system, and the slightly cuneate outline show their congeneric relation to the species considered in the preceding sections, some of the cuneate forms thus approaching the *W. microphylla*. Remark should be made of the presence, about 470 feet below the Buck Mountain coal, of a straight, normally cuneate-linear form attaining a length of 35 mm. and a width of 6 mm.

As with the other species of the genus, none of the leaves of *Whittleseya Campbelli* have yet been seen with absolute certainty to be attached to any branch or axis, though they are sometimes found in large numbers matted together, their bases obliquely converging toward a common axis. I suspect the fruits of the plant to be referable to *Rhabdocarpos*.

Whittleseya Campbelli[1] is at once distinguished by its linear form and small size from all the species of the genus yet described.

The species occurs at nearly all localities of the Pottsville formation in horizons below the Fayette sandstone of Virginia, the Conoquen-

[1] The species is named in honor of my esteemed colleague, Mr. M. R. Campbell, geologist in charge of the areal cartography of the Central Appalachian coal fields, to whom I am greatly indebted for abundant assistance in the collection of fossil material from all possible localities in that region as well as for valuable stratigraphic data.

nessing sandstone of northwestern Pennsylvania, and the upper plexus of conglomerates in the anthracite regions. In the Southern Anthracite field it is found at a number of horizons in the Pottsville Gap, the Swatara Gap, Rausch Gap, the Lincoln and Brookside mines, the Eureka tunnels, Williamstown and Big Lick mines, Millers drift, Kalmia mine, and the Kemble drift. A very large form occurs at about 450 feet below the Twin coal in the Pottsville Gap. The elongated type mentioned above occurs in the roof of Lykens coal No. 2 at the lower Eureka tunnel and at the New Lincoln mine. A type probably representing the same form occurs at 380 feet below the Twin coal in the Pottsville Gap.

Cardiocarpon Girtyi sp. nov.

Pl. CXCIII, Fig. 11.

Seeds flat, or nearly so, not very large, ovate-cordate, 10 to 11 mm. long, 10 mm. in diameter at the broadest point, a very little below the middle, with rather shorter nucleus, rounded at the base, apiculate at the top, and bordered by an extremely broad wing; wing nearly circular in form, 9 to 13 mm. in width, slightly cordate by a shallow sinus at the point of contact with a not very distinct chalaza, a little broader on either flank of the base, and a little narrower at the immediate top, where it is cut to a depth of 2 mm., with rounded edges, in a narrow, acute, micropylar sinus.

The conspicuous features of this species are the nearly circular form of the wing and the great breadth of the latter, which nearly equals, if not exceeds, the longer diameter (1 cm.) of the nucleus. As may be observed by an inspection of the figure, Pl. CXCIII, Fig. 11, the nucleus is somewhat shorter than the outer test. From the intermediate space at the apex the micropylar tube passes, as a thickened double line, to the angle of the sinus. A slight, somewhat cuneate, thickening of the chalaza at the base of the nutlet may also be seen. *Cardiocarpon Girtyi*, together with *Cardiocarpon Phillipsi*, *C. Newberryi*,[1] *C. samaraeforme*,[2] *C. annulatum*,[3] *C. dilatatum*,[4] and *C. ingens*,[5] constitute a group of large, broad-winged species of the genus, whose occurrence is characteristic of the Upper Lykens division or the Sewanee zone of the Pottsville, although some of the species occur very near to the upper limit of the formation. *Cardiocarpon Baileyi*,[6] from the so-called middle Devonian at St. John, New Brunswick, appears to be a very closely related species. This group seems also to bear a close affinity to the Old World fossils described by Fiedler[7] as *Jordania bignonioides* and *J. oblonga*.

[1] Andrews, Rept. Geol. Survey Ohio, 1875, Vol. II, Pt. I, p. 425, pl. xliv, fig. 2.
[2] Newberry, Rept. Geol. Survey Ohio, 1873, Vol. I, Pt. II, p. 375, pl. xliii, figs. 11, 11a.
[3] Op. cit., p. 374, pl. xlii, fig. 8.
[4] Coal Flora, Vol. III, p. 806, pl. cx, fig. 2.
[5] Op. cit., Vol. II, p. 563, pl. lxxxv, figs. 34, 35.
[6] Dawson, Fossil Plants of the Devonian and Upper Silurian Formations of Canada, 1871, p. 60, pl. xix, fig. 219.
[7] Foss. Früchte d. Steinkohlenfl., p. 51, pl. xxvii, figs. 36, 37, 43–45.

Cardiocarpon cornutum Dn.

Pl. CXCIII, Fig. 10.

Specimens agreeing with material from the type locality at St. John, New Brunswick,[1] occur in the Southern Anthracite field in the vicinity of Lykens coals 2 and 3 at the New Lincoln mine, and at 550 feet below the Twin coal in the Pottsville Gap.

Cardiocarpon biscupidatum (Sternb.) Newb. var. ohioense n. var.

The doubt expressed by Dr. Newberry[2] as to the identity of the fruits in the roof of coal No. 1 (Sharon) with the type described by Sternberg[3] seems to be fully justified by a comparison of the material representing the American form from Ohio, Pennsylvania, Tennessee, and Arkansas with the figures published by Sternberg. The specimens from the Sewanee zone in our Coal Measures are much broader proportionately, and larger, while but the slightest trace of a cusp is seen at the base in any example, the slight cusp at the apex being often situated in the midst of the somewhat concave profile of the upper margin of the nucleus. The American type, as figured by Newberry, and as represented in figs. 20 and 22, pl. cx of the Coal Flora, I have distinguished as the var. *ohioense*. This form, which deserves additional illustration, I have nowhere seen below the Sewell formation, or the Upper Lykens division, although it ascends to near the top of the Pottsville. Typical examples are found in the Southern Anthracite field at the drift in the upper Lykens coal in Yellow Springs Gap, and in the shale from a drift below the trolley road on the east side of the gap at Pottsville, in a horizon 380 feet below the Twin coal.

Cardiocarpon elongatum Newb.

The species described by Newberry[4] under this name represents one of the most widely distributed and characteristic as well as comprehensive types of the Sewanee zone. Between it and the broader forms, such as *Cardiocarpon late-alatum*[5] Lx., there is a series of intermediate forms, although few of the latter are at any point found in the same beds. In the Southern Anthracite field, as in the region of the Sharon coal in northwestern Pennsylvania and northern Ohio, the species is sometimes found associated with *Cardiocarpon minus*[6] and *C. annulatum*.

[1] Dawson, Quart. Jour. Geol. Soc. London, Vol. XVIII, 1862, p. 324, pl. xiii, figs. 23, 24; Fossil Plants of the Devonian and Upper Silurian Formations of Canada, p. 60, pl. xix, figs. 214–218.

[2] Rept. Geol. Survey Ohio, 1873, Vol. I, Pt. II, p. 373, pl. xliii, figs. 9, 9a.

[3] Flora d. Vorwelt, Vol. I, fasc. I, pl. vii, fig. 8.

[4] Annals Sci., Cleveland, Vol. I, p. 153, fig. 6; Rept. Geol. Survey Ohio, 1873, Vol. I, Pt. II, p. 373, pl. xliii, fig. 5.

[5] Lesquereux, Coal Flora, Vol. II, 1880, p. 568, pl. lxxxv, figs. 46, 47.

[6] Newberry, Rept. Geol. Survey Ohio, 1873, Vol. I, Pt. II, p. 373, pl. xliii, fig. 4.

Cardiocarpon obliquum Dn.

The identification in the Southern Anthracite field of this species, hitherto known only from the so-called middle Devonian at St. John, New Brunswick,[1] rests upon the entire agreement of the American examples with specimens from the type locality of the species. This fruit, which appears to me to be unquestionably distinct from *C. acutum* L. and H., is especially common at the drift in the upper Lykens coal at Kohlers Gap, in Bear Mountain. It is also found in the roof of Lykens coal No. 2 at the North Brookside slope, and in the rock dump from the Upper Lykens coals at the New Lincoln mine.

Cardiocarpon cuyahogæ nom. nov.

This name is here proposed for the fruits which were described by Newberry[2] as *Cardiocarpon orbiculare*, the latter name having been employed in the preceding year by Ettingshausen[3] for a similar fruit. The species occurs in the roof of Lykens coal No. 2 at North Brookside, at the lower Eureka tunnel, and at the New Lincoln mine. It has also been found in the rock dump from the upper Lykens coals at the Lincoln mine.

Trigonocarpum ampullæforme Lx.

Pl. CXCI, Fig. 8.

Examples of this species from the anthracite regions appear to agree in all respects with the types described by Lesquereux[4] from the Sewanee zone in Tennessee and Arkansas. Throughout the greater portion of the Appalachian region this type of fruit is more common in and slightly characteristic of the Sewanee zone. I have not yet seen the species in the Lower Coal Measures.

Trigonocarpum Helenæ sp. nov.

The species of fruit which will eventually be described under this name includes a portion of the types described by Lesquereux[5] from the Pottsville formation in Alabama as *Rhabdocarpos clavatus?* Gein. *Trigonocarpum Helenæ* is distinguished from *Trigonocarpum ampullæforme* var. *spectabile* by the generally narrower nuclei, the very much narrower and less prominent ribs, and the proportionately thicker envelopes with their relatively much broader, shorter, micro-

[1] Dawson, Quart. Jour. Geol. Soc. London, Vol. XVIII, 1862, p. 324, pl. xiii, fig. 25; Fossil Plants of the Devonian and Upper Silurian Formations of Canada, 1871, p. 61, pl. xix, figs. 225–226.

[2] Annals Sci., Cleveland, Vol. I, 1853, p. 153; Rept. Geol. Surv. Ohio, Vol. I, Pt. II, 1873, p. 374, pl. xliii, fig. 10.

[3] Steinkohlenfl. v. Stradonitz, 1852, p. 16, pl. vi, fig. 4.

[4] Coal Flora, Vol. III, p. 823, pl. cix, figs. 18–21. Nos. 16536–16538, Lacoe Coll., U. S. National Museum,

[5] Coal Flora, Atlas, p. 18, pl. lxxxv, fig. 20 (not fig. 14); text, Vol. II, 1880, p. 581 (part).

pylar necks. *T. pusillum* Brongn. is much shorter and more pointed, besides having less distinct ribs. The type from St. John, New Brunswick, which I have designated *T. Dawsonianum* differs from *T. Helena* by its still more slender form and narrower acuminate valves. This species is, in the central and southern Appalachian regions, apparently confined to the Clark and Quinnimont formations; and more particularly to the basal portion of the latter. In the Southern Anthracite region the fruit has, however, a much greater range, examples having been collected from the roof shales of Lykens coals Nos. 4 or 5 at the Lincoln, Brookside, and Kalmia mines, and from the upper Eureka tunnel. It also occurs in the rock dump from the upper Lykens coals at the New Lincoln mine, as well as at the supposed horizon of Lykens coals Nos. 2 and 3 in the Pottsville Gap.

Trigonocarpum Dawsonianum sp. nov.

Accompanying the specimens of a very narrow and rather small *Trigonocarpum*, there occur in the same matrix numerous detached valves which agree so completely with the fragments figured by Dawson from the "Fern Ledges" at St. John as "fruits or bracts of uncertain nature," that I have ventured to include a portion of the latter material as well, in the same species. The figures given in the "Devonian flora"[1] will serve to illustrate the Pottsville material which I name in honor of the late distinguished paleobotanist of America. The differences between *T. Dawsonianum*, which will later be more fully described and illustrated, and *T. Helena* have already been indicated. The species is found in the roof of Lykens coal No. 4 at the Lincoln mine and at the Kemble drift. It also occurs in the rock dumps at East Brookside and at the New Lincoln mine. Examples probably belonging to the same type occur in the plant beds 550 feet below the Twin coal in the gap at Pottsville.

Carpolithes transsectus Lx.

Detached semicircular bracts, or possibly sporangiophores, identical in form with those described by Lesquereux[2] from the "coal-bearing shale" of Washington County, Arkansas, occur at a number of localities in the shales from the coals of the Upper Lykens division. The structure of the organ from which these small semidiscoid fossils are derived is still uncertain. From their mode of occurrence and their association, I am, however, disposed to regard them as possibly belonging to a strobile similar to or identical with that described by Lesquereux[3] as *Lepidocystis quadrangularis*.

[1] Fossil Plants of the Devonian and Upper Silurian Formations of Canada, 1871, pp. 64, 92, pl. xix, figs. 230a, 231, 231a–b (not fig. 230).

[2] Coal Flora, Vol. III, p. 826, pl. cxi, figs. 27, 27a–b.

[3] Op. cit., Vol. II, p. 455, pl. lxix, fig. 5.

FAYOLIA sp.

Although the collections in the National Museum already contain specimens from the Allegheny series (XIII) at Mazon Creek, Illinois, referable to this genus, it is represented, so far as I know, in the collections from the Pottsville series by only two obscure specimens.

From an examination of the material from Mazon Creek, and of the types from the Chemung of northwestern Pennsylvania, described by Dr. Newberry as *Spiraxis*,[1] I am convinced that the latter genus is essentially identical with the *Fayolia*[2] of the Old World.

AGE OF THE POTTSVILLE FORMATION.

In the absence of the full descriptive paleontologic evidence, I should prefer to refrain from a definite statement of conclusions as to the age or the equivalents of the Pottsville formation. Since, however, the questions of age and correlation directly affect the classification and nomenclature of the formations now being mapped in the Appalachian province, it is proper to offer a few brief generalizations which may be considered as preliminary and, so far as they relate to European coal fields, as tentative or suggestive.

The persistency of the formation, or some portion of it, in some phase or other throughout the American Carboniferous basins, its generally well-marked lithologic characters, the different conditions governing its deposition, its thickness, which may exceed 2,500 feet in the Virginia-Tennessee region, and its mostly very distinct vegetable contents, as compared with the basal portion of the Lower Coal Measures, or the Allegheny series, in Pennsylvania and Ohio, appear to me to merit for these terranes distinct recognition as a formation or series, coordinate not only with the Allegheny series, Conemaugh series, etc., but with Lower, Middle, and Upper Coal Measures, as those terms are used in this country. It is to be regretted that while under the name "Pottsville series" the formation is ranked by most geologists with Allegheny series,[3] etc., many authors treat it as a part of the Lower Coal Measures, although it was originally distinguished by Rogers as coordinate with the latter. Its occasional inclusion by geologists in the more comprehensive, but equivocal, "Coal Measures" is perhaps not wholly satisfactory, even when that term is used in the broader sense of "Upper Carboniferous." As has already been remarked, no conclusive proof that the oldest beds of the Pottsville may be contemporaneous with the last beds of the red shale, or other marine Lower Carboniferous sediments, has yet come to light. Nevertheless, if the explanation of the conditions of the deposition of the

[1] Newberry, Annals New York Acad. Sci., Vol. III, 1885, p. 217.

[2] Renault and Zeiller, Comptes Rendus Acad. Sci., Vol. XCVIII, p. 1393; Fl. Foss. bassin houill. Commentry, 1888, Pt. I, p. 15; Pt. II, 1890, p. 369.

[3] Bull. U. S. Geol. Survey No. 65, p. 129.

formation here accepted is correct, it is possible that there is a slight overlap of Pottsville time on that of the Mauch Chunk formation, in which case its designation as Coal Measures would be lithologic and economic only, rather than strictly accurate from the chronologic standpoint.

The flora of the Vespertine (Pocono X), which has received attention from Lesquereux[1], Meek[2] and Fontaine,[3] like that of the corresponding Horton series of Nova Scotia, studied by Sir William Dawson, consists of an almost exclusively *Triphyllopterid* or *Aneimites* flora, with several laciniate-lobed *Sphenopterids*, and great numbers of *Lepidodendron* of the *corrugatum* type. The flora of the Mauch Chunk formation is as yet but little known; but such material as has come to hand from the upper portion of the formation shows a marked affinity with the Pottsville flora. The Chester limestone of Illinois is said to have furnished some fossils which are closely related to those of the basal Pottsville beds. I may add that the *Aneimites* from the topmost bed (bed A, Pl. CLXXXII) of the red shale at the Westwood and Pottsville gaps appears to be more closely bound to the Lower Carboniferous types than to the ordinary plant life of the Pottsville formation, and should, therefore, perhaps be excluded, together with the accompanying *Sphenopteris umbratilis*, from the flora under consideration.

The plants of the Lower Lykens division, as a whole, appear to stand in the closest relation to the flora of the Ostrau-Waldenburg beds described by Stur[4] and generally regarded as Lower Carboniferous ("Culm"), though many geologists and paleontologists are strongly disposed to refer the terranes to the Millstone grit. The intimacy of the relationship, and the probable contemporaneity of our flora with the Upper Culm flora will be more fully indicated when the Pottsville flora is treated more at length, in the monographic report.

The flora of the Upper Lykens division seems to be directly related to that of the Millstone grit of Canada and portions of the Carboniferous basins of the Old World, though the data for comparison are hardly satisfactorily complete. The upper horizons of this division have also much in common with the flora of the Lower Coal Measures of Great Britain. The latter, it may be noted, are, for the most part, paleobotanically older than the formation known by the same name in the Northern States of this country.

The Upper Intermediate division would seem, from the identities and distribution of its plant species, to be as late as the Lower Coal Measures of Great Britain, or the lower zones of the Westphalian in continental Europe.

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[1] Geol. Pennsylvania, 1858, Vol. II, Pt. II.
[2] Bull. Philos. Soc. Washington, 1879, Appendix.
[3] Am. Jour. Sci., 3d series, Vol. XIII, 1877, pp. 35, 115.
[4] Abh. d. k.-k. geol. Reichsanst., Vol. VII, 1877, Pt. II.

One of the most surprising, as well as interesting, facts observed in the study of the Pottsville floras is the large element that is common to the latter and to the flora described by Sir William Dawson from the supposed middle Devonian beds at St. John, New Brunswick. In fact, taking into view the entire flora of the Pottsville formation in the Appalachian province, the identities in the composition of the floras are so great, with respect to both genera and species, as to leave little room for doubt that we have in the "Fern Ledges" at St. John beds of nearly the same age as the Pottsville formation in Pennsylvania. In fact, as has been remarked in the preceding notes, the characteristic forms of the St. John flora, such as *Megalopteris*, *Neuropteris retorquata*, *Alethopteris discrepans*, *Alethopteris ingens*, *Sphenopteris pilosa*, *Sphenopteris Harttii*, *Sphenopteris marginata*, *Pecopteris serrulata*, *Annularia latifolia*, and *Annularia acicularis*, as well as the numerous gymnospermous fruits, are so far identical with, or obviously most intimately related to, the upper Pottsville types as to render it highly probable that a flora contemporaneous with that of the Sewanee zone is present in the section along the St. John Harbor.

On the whole, as may already have been inferred, while recognizing in the Pottsville formation a group of terranes equal in rank to Lower Coal Measures, Allegheny series, etc., I not only do not favor a classification which relegates the entire formation hard and fast to the Upper Carboniferous, but I even anticipate a possible necessity for its permanent division into two groups, the lower of which may eventually perhaps be referred to the Lower Carboniferous. From the paleobotanic standpoint the Pottsville formation is the beginning of the Mesocarboniferous.

SUMMARY OF CONCLUSIONS.

1. The Pottsville formation in the Southern Anthracite field is composed chiefly of massive conglomerates and conglomeratic sandstones of varying composition, the lower terranes being somewhat heterogeneous and irregular, the upper generally more uniform and persistent, with better assorting of materials. The coals (Lykens), locally of great economic importance, exhibit the general variability of the formation, though they sometimes appear to extend over relatively large areas.

2. In the Schuylkill region the passage from the Mauch Chunk (XI) to the Pottsville (XII) is by a transition of heterogeneous conglomerates, intercalated in red and green shales, the proportion of sandstones increasing to the top of the red shales, which are later represented by red and green argillaceous materials washed into the soft but more distinctly arenaceous conglomerates and bowlder beds of the lower portion of the Pottsville.

3. The irregularity and the lack of selection in the materials interlarded with the upper beds of red and green shales (Mauch Chunk) appear to be natural results of the submergence and somewhat imperfect working-over of an intermittently subsiding coastal plain under the action of strong and varying detritus-laden currents.

4. No evidence of a marked or general unconformity between the Pottsville and Mauch Chunk is noticeable in this region, though at various points within several hundred feet of strata beds of small bowlders or coarse conglomerates are imposed, in a knife-edge contact, on the distinctly uneven surfaces of olive-green mud beds.

5. The conditions are such that it is impossible to determine upon a persistent stratigraphic basal line of division which can be traced or recognized throughout the basin. Different geologists have taken different horizons. In this report the topmost bed of typical red shale or sandstone in the section is arbitrarily taken as the upper limit of the Mauch Chunk. This is the usage of geologists in the bituminous fields, where, it should be noted, an unconformity probably exists in most areas.

6. The upper limit of the Pottsville formation has, for reasons of necessity or practicability, been placed by the various geologists and surveys of Pennsylvania at the base of the lowest "considerable coal," which usually occurs not far above the main plexus of massive conglomerates at the top of the Pottsville formation. Such a horizon, though usually traceable for a distance of several miles, is not always definite where, as happens in portions of the field, the distinctly conglomeratic character of the terranes continues into the Coal Measures and a number of thin coals are interspersed. Yet this mode of delimitation, employed in conjunction with the knowledge of the stratigraphic relations of the low coals to the main upper group of conglomerates, has probably rarely led to any considerable vertical error throughout the central portion of the field, including the vicinity of the type section; and, from the standpoint of field practicability, it is probably the most satisfactory method of definition at present available.

7. The flora in the roof of the Buck Mountain coal, or its supposed equivalents, at the very base of the Lower Coal Measures at Pottsville is a typical Coal Measures flora, very distinct from the floras typical of the Pottsville formation, although a few of its species appear in the upper 250 feet of beds in the latter, which contain a mixed flora. It is even slightly later than that of the basal beds of the "Lower Coal Measures"[1] in the Northern Anthracite field or of the Allegheny

[1] The term Lower Coal Measures is used in the anthracite fields in the original sense as proposed by Rogers for the series next above the Seral (Pottsville) conglomerate. It is similarly applied in the northern bituminous basins, where it is, in part at least, synonymous with Allegheny series, Desmoines series, etc. It is, however, shown by the fossil plants to be as a whole somewhat later than the Lower Coal Measures of the Old World. See Bulletin of the Geological Society of America, Vol. XI, pp. 145–178.

series in the northern bituminous basins. Furthermore, the plants from the thinner coals in the type region, in some cases about 100 feet or more lower than the "Buck Mountain" (Twin) bed, and close to or partly within the top of the upper dense complex of conglomerates, with which the formation culminates, are also clearly paleontologically referable to the Lower Coal Measures, they being comparable to the lowest floras above the Homewood sandstone in the bituminous basins. In other words, the conventional stratigraphic boundary between the Pottsville formation and the Lower Coal Measures is, in the Southern Anthracite field, slightly higher than the paleontologic boundary. The paleontologic boundary appears to lie close within the outskirts of the upper plexus of conglomerates which form the most conspicuous feature of the formation from the Pottsville Gap westward.

8. In the central districts of the field the formation probably attains its maximum thickness of a little more than 1,200 feet. Westward it thins very gradually on the whole, the thickness at Rattling Run Gap being 1,100 feet. Eastward it appears to rapidly decrease to about 830 feet at Tamaqua, and perhaps less than 800 feet at the Lansford railroad tunnel, though it seems to expand somewhat to the eastward of this point near the apex of the field. Little, if any, diminution is observed within this field in passing from south to north.

9. The fossil plants of the Pottsville formation in the type region exhibit a rapid development and series of changes or modifications, which, if treated with great systematic refinement, are of high stratigraphic value. With the exception of the species from the topmost beds of the formation, the ferns are, in general, readily distinguished specifically from those at the base of the Lower Coal Measures, or Allegheny series, as recognized in the northern United States, while the floras of the lower portions of the section are found, in passing downward, to bear still less resemblance to those of the Lower Coal Measures. Two principal divisions of the formation, to which comparatively few fern species are common, are recognized. These divisions, which coincide with the natural grouping of the Lykens coals, are here termed the Lower Lykens division and the Upper Lykens division. A portion, including about 200 feet of the type section between these two paleontologic divisions, contains a mixed flora, and has been temporarily designated the Lower Intermediate division. A portion of the type section, at about 200 feet below the Buck Mountain coal, contains floras largely characteristic of the Pottsville, but in association with a number of the earliest Coal Measures species. This is temporarily termed the Upper Intermediate division. The Lower Lykens division includes two floral zones, (1) that of the lowest beds, up to and including the roof shales of Lykens coal No. 5, and (2) that of the vicinity of Lykens coal No. 4. The first contains

relatively few ferns, and is specially characterized by the invariable abundance of a species of *Neuropteris*, as well as by the absence of the forms typical of the other zone. The Upper Lykens division reveals a principal zone of the Sewanee-Sewell coal flora, typically present in the vicinity of Lykens coals Nos. 3 and 2, but extending in modified form up to Lykens coal No. 1. The flora of the latter horizon is characterized by modified survivors from the older horizons of the Sewanee zone, accompanied by elements apparently peculiar to this portion of the section.

10. The flora of the lower zone of the Lower Lykens division is found in the vicinity of the Pocahontas coal in the very thick section of the Pottsville formation in the Virginia-Tennessee region. It is unknown in the thinner sections along the northern and western borders of the Appalachian trough. Beds contemporaneous with the upper zone of the same division are present in the upper portion of the Clark and in the Quinnimont formations of Virginia and West Virginia and in the Lookout formation of the Tennessee-Alabama region. The Lower Intermediate division of the formation in the Southern Anthracite field is shown by the fossils to occupy nearly the position of the Raleigh sandstone in the Virginia region and of the Sewanee conglomerate, the top of the Lookout, in Tennessee. The flora ("Sewanee") in the lower portion of the Upper Lykens division is essentially identical with that in the vicinity of the Sewanee coal in the lower portion of the Walden sandstone in the Alabama-Tennessee region, the Sewell and the Dismal formations and a portion of the Norton formation in the Virginia region, and the Sharon coal of northern Pennsylvania and Ohio. The lowest phytiferous horizons of the formation yet studied in the bituminous basins of Pennsylvania and northern Ohio appear to be distinctly referable to this zone. It is doubtful whether beds older than the upper portion of the Quinnimont formation are present in these regions. The upper and less distinct zone of the Upper Lykens division appears to be represented in the greatly expanded later modification of the Sewell formation of Virginia and southern West Virginia, near the base of the Fayette formation. The time of the upper 200 or 300 feet of ponderous conglomeratic plates at the top of the formation, constituting the Upper Intermediate division in the Southern Anthracite field, is apparently represented by over 800 feet of sediments in the southern Virginia region, only the lower portion of which, including, probably, a part of the Fayette formation, has the lithologic characters of the Pottsville. The horizon of the well-known plant bed at Campbell Ledge, which is within a few feet of the supposed Mauch Chunk, in the Northern Anthracite field, is probably not lower than this division of the type section.

11. Further paleobotanic study of the Pottsville formation appears to fully confirm the earlier conclusion, based on the examination of the plants, that the thinner sections of the formation along the northern and western borders of the Appalachian trough do not contain beds as old as those in the lower portions of the thick sections along the eastern border, e. g., in the Schuylkill and Great Flat Top regions. The positions of the respective floras in the sections plainly indicate a transgression of the sea toward the north and west during Pottsville time.

12. Both lithologically and paleontologically the Pottsville formation constitutes a division of the Carboniferous coordinate with the "Lower Coal Measures," "Allegheny series," etc. As such it forms the lower member of what may, in a broad sense, be termed the Mesocarboniferous in the Appalachian province.

13. The lowest beds in the thickest sections, which appear to be continuous by transition with the deposition of the Mauch Chunk red shales, are perhaps to be regarded as coarse, coast-detrital redepositions, contemporaneous with the uppermost beds of red shale or other marine Lower Carboniferous sediments in other regions. The flora of the Lower Lykens division appears to be contemporaneous, in part at least, with that of the Ostrau-Waldenburg (Culm) beds of the Old World. The flora of the Sewanee zone of the Upper Lykens division is perhaps contained in the Millstone grit of Canada and portions of the Old World coal fields, while it is probable that the Upper Intermediate division is contemporaneous with a part of the Lower Coal Measures (Westphalian) of Europe.[1]

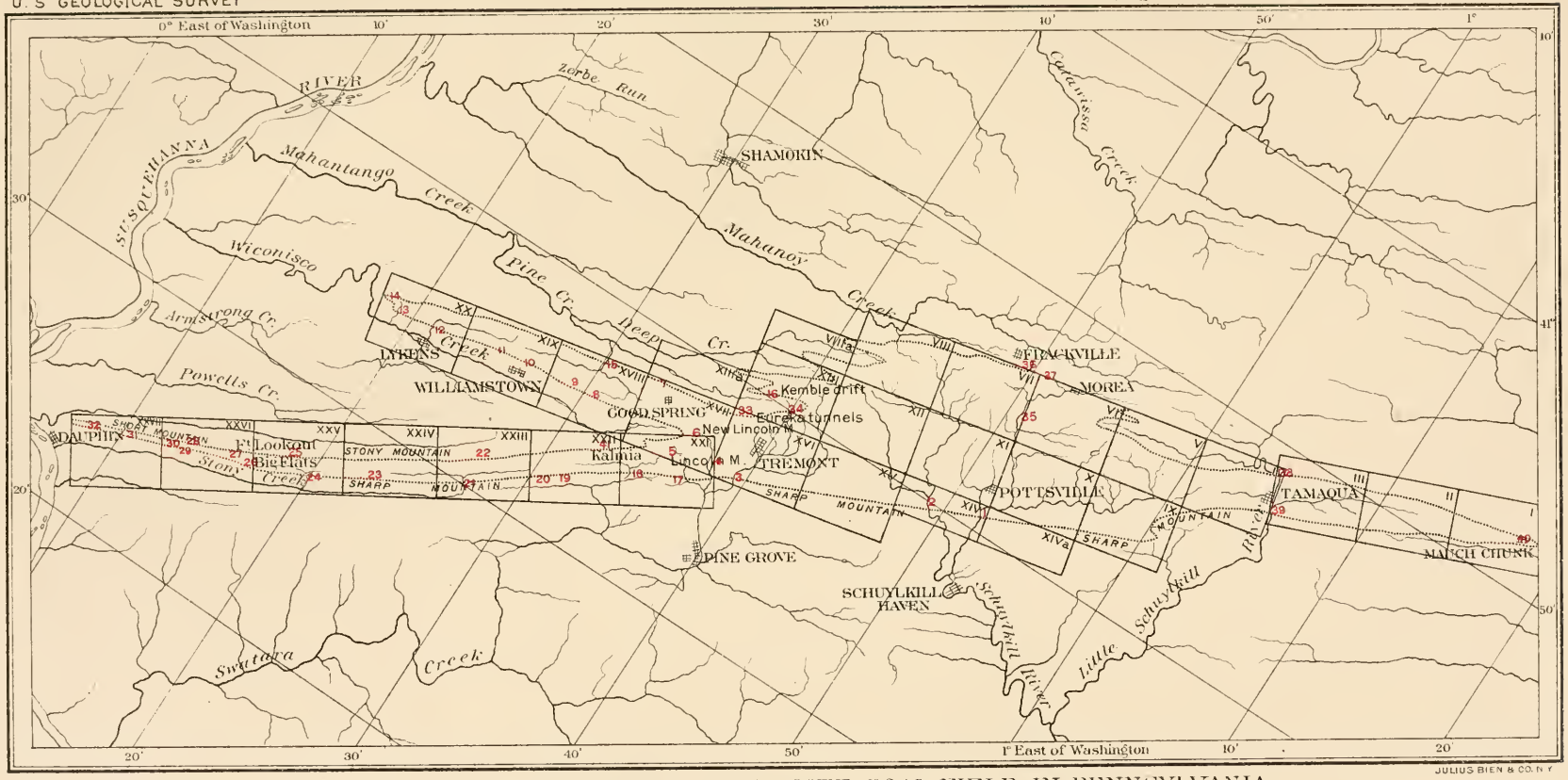
14. The flora of the Pottsville formation is so far identical, in both its generic and its specific composition, with that from the supposed middle Devonian beds at St. John, New Brunswick, as to leave no room for a great difference in the age of the latter. In fact, the plants from the "fern ledges" include a flora essentially equivalent to that of the Sewanee zone, which appears to be represented by a portion of the section at St. John.

15. Owing to the hitherto unrecognized presence of an overthrust in Sharp Mountain in the vicinity of Lorberry Gap,[2] and the consequent misidentification of the less valuable coals in Lorberry and Fishing Creek gaps with the Lykens coals, the boundary of the lowest Lykens coal has been represented from Fishing Creek Gap westward, on the State mine maps, as close to or north of the crest of

[1] The base of the Lower Coal Measures or Allegheny series in this country appears paleontologically to be nearer the stage of the Middle Coal Measures of Great Britain, or the upper zone of the Westphalian in continental Europe.

[2] The discovery of the fault at Lorberry and Fishing Creek gaps was the direct result of the testimony of the fossil plants, which was later completely corroborated by the ordinary stratigraphic method.

Sharp Mountain, i. e., near the place of the Buck Mountain bed, whereas the outcrop of nearly the entire Pottsville formation, in its full thickness, including both of the groups of Lykens coals, extends from near Fishing Creek Gap nearly to the Big Flats, a distance of over 17 miles along the south face of Sharp Mountain, quite outside of the "approximate boundary of the lowest Lykens coal" and partly within the territory represented on the anthracite maps of the recent State geological survey as Mauch Chunk red shales.



KEY MAP OF THE SOUTHERN ANTHRACITE COAL FIELD IN PENNSYLVANIA

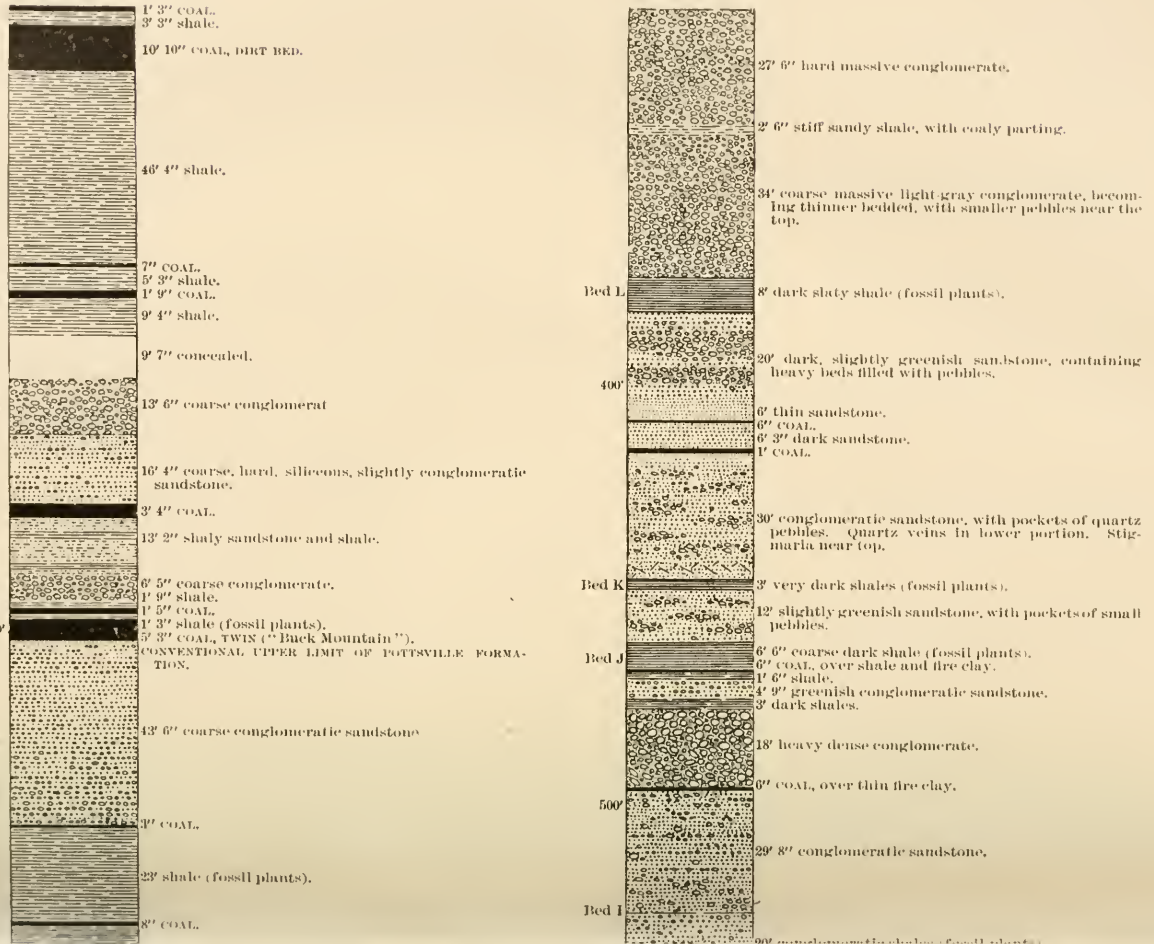
Showing locations of sections and collections, and areas included in the state mining maps

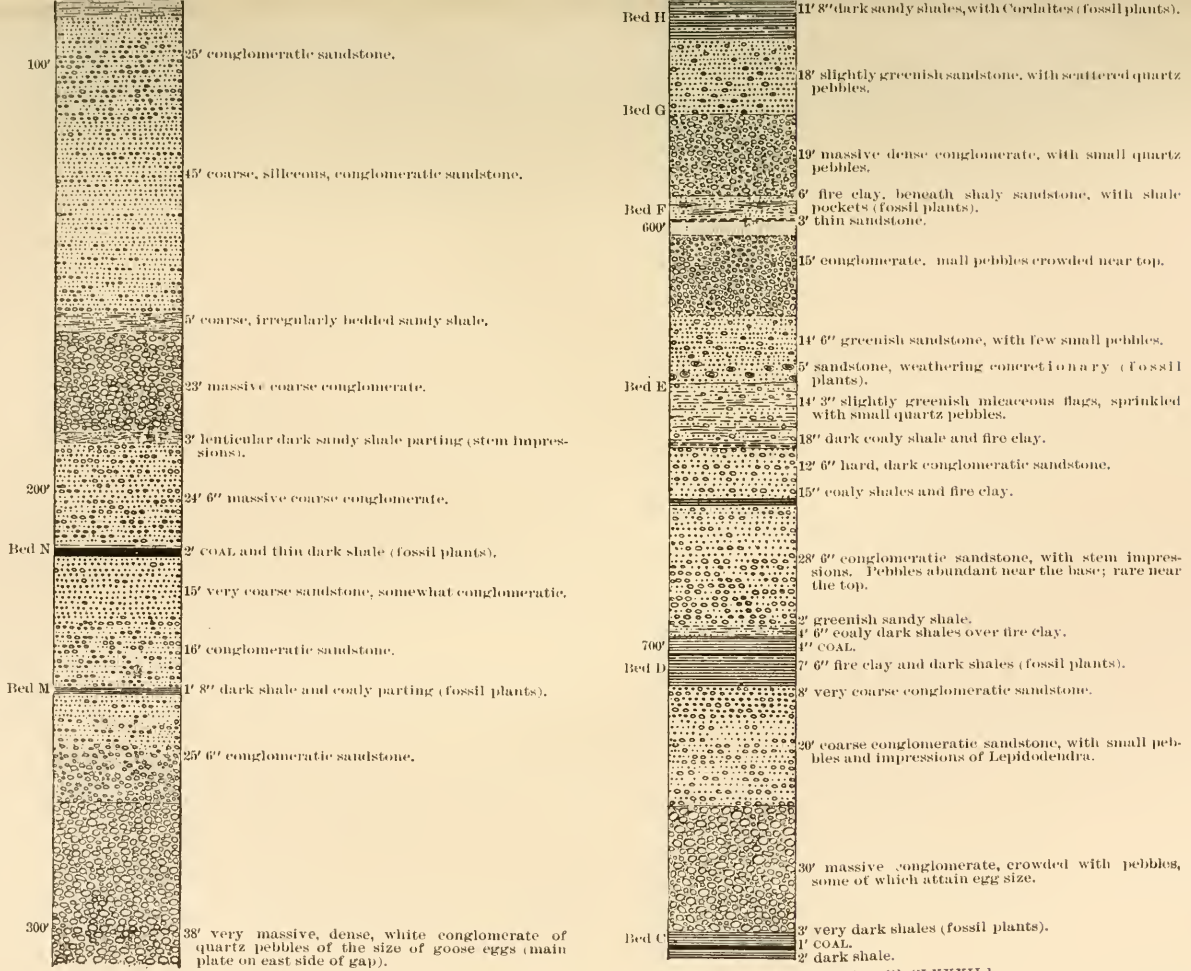
Scale

5 0 5 10 15 MILES

Compiled from the Anthracite reports of the state geological survey

1898.

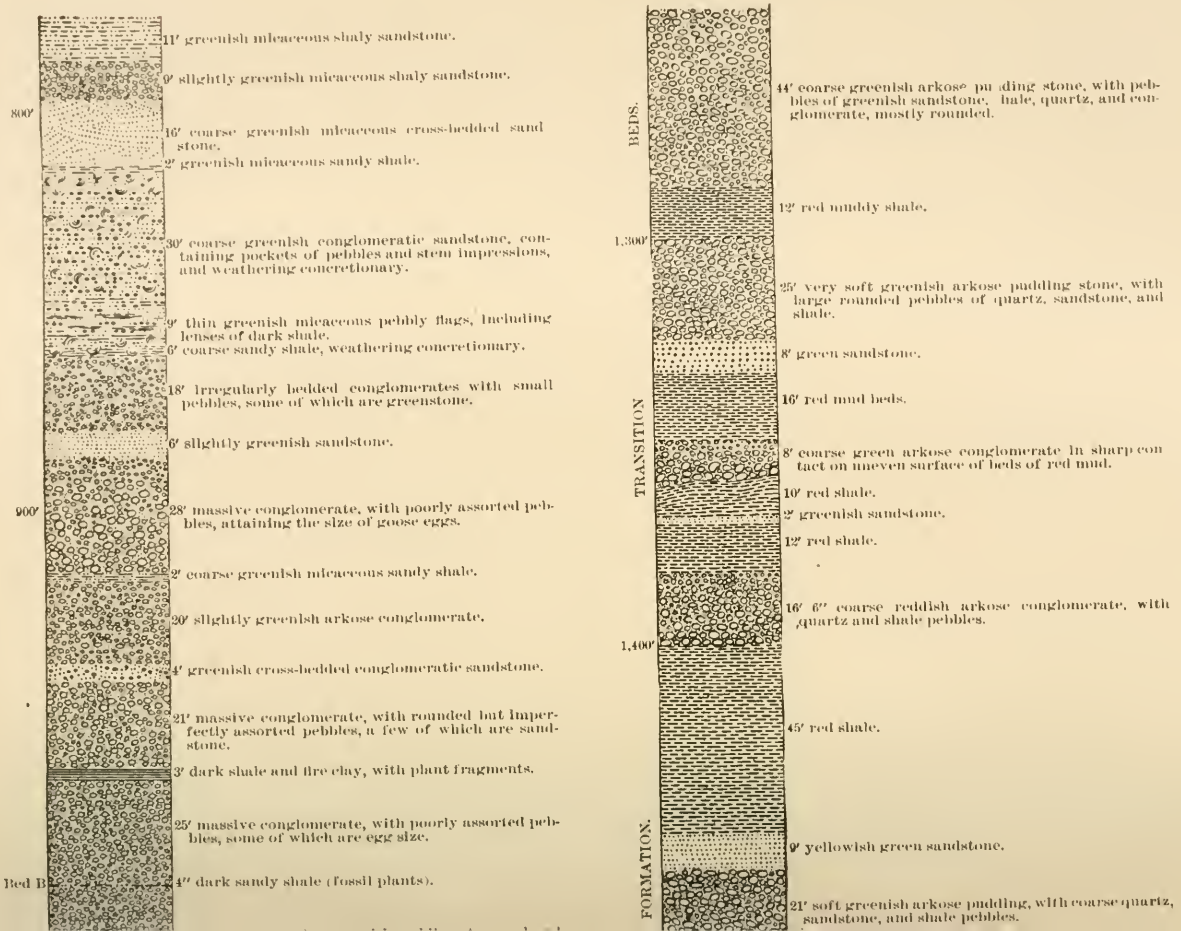

1′ 3″ COAL.
3′ 3″ shale.
10′ 10″ COAL, DIRT BED.
46′ 4″ shale.
7″ COAL.
5′ 3″ shale.
1′ 9″ COAL.
9′ 4″ shale.
9′ 7″ concealed.
13′ 6″ coarse conglomerat
16′ 4″ coarse, hard, siliceous, slightly conglomeratic sandstone.
3′ 4″ COAL.
13′ 2″ shaly sandstone and shale.
6′ 5″ coarse conglomerate.
1′ 9″ shale.
1′ 5″ COAL.
1′ 3″ shale (fossil plants).
5′ 3″ COAL, TWIN ("Buck Mountain").
CONVENTIONAL UPPER LIMIT OF POTTSVILLE FORMATION.
43′ 6″ coarse conglomeratic sandstone
3″ COAL.
23′ shale (fossil plants).
8″ COAL.
"LOWER COAL MEASURES"
POTTSVILLE FORMATION.
27′ 6″ hard massive conglomerate.
2′ 6″ stiff sandy shale, with coaly parting.
34′ coarse massive light-gray conglomerate, becoming thinner bedded, with smaller pebbles near the top.
Bed L
8′ dark slaty shale (fossil plants).
20′ dark, slightly greenish sandstone, containing heavy beds filled with pebbles.
400′
6′ thin sandstone.
6″ COAL.
6′ 3″ dark sandstone.
1′ COAL.
30′ conglomeratic sandstone, with pockets of quartz pebbles. Quartz veins in lower portion. Stigmaria near top.
Bed K
3′ very dark shales (fossil plants).
12′ slightly greenish sandstone, with pockets of small pebbles.
Bed J
6′ 6″ coarse dark shale (fossil plants).
6″ COAL, over shale and fire clay.
1′ 6″ shale.
4′ 9″ greenish conglomeratic sandstone.
3′ dark shales.
18′ heavy dense conglomerate.
6″ COAL, over thin fire clay.
500′
29′ 8″ conglomeratic sandstone.
Bed I

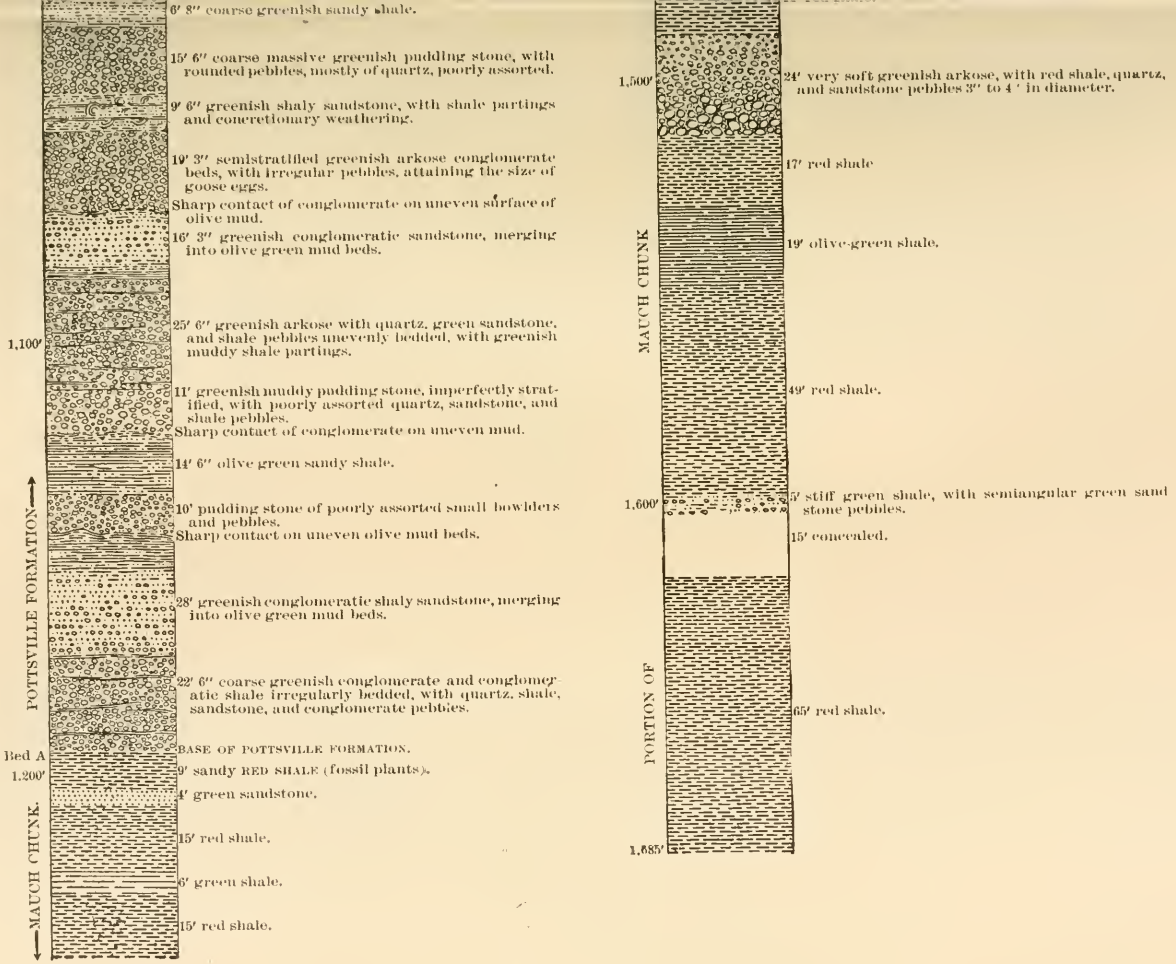


[This section is continued on Pl. CLXXXII.]

SECTION IN SHARP MOUNTAIN GAP, POTTSVILLE, PENNSYLVANIA.

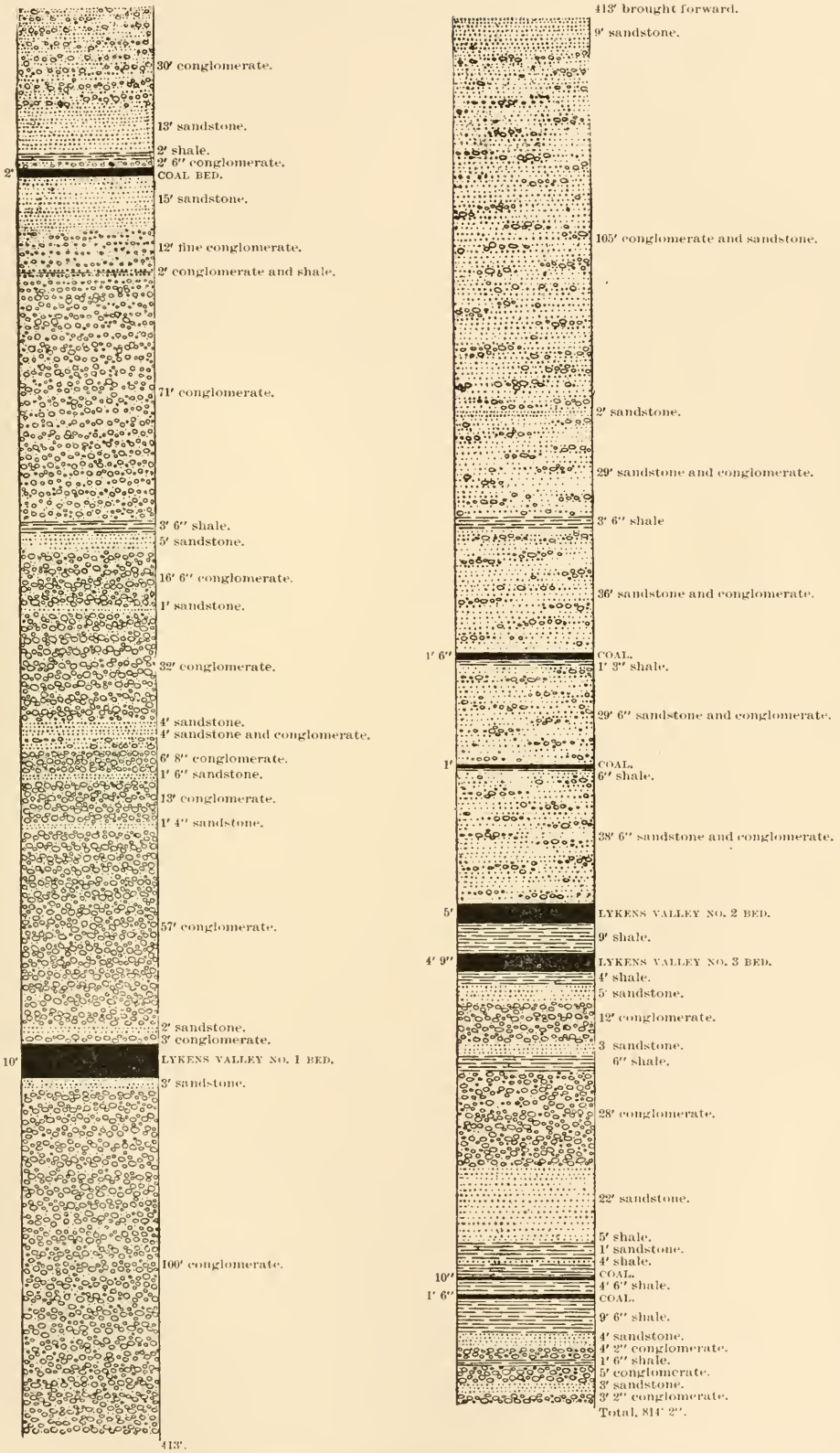
From the "dirt" bed downward into the red shale, including the type section of the Pottsville formation and portions of the overlying "Lower Coal Measures" and of the underlying Mauch Chunk formation.


11′ greenish micaceous shaly sandstone.
9′ slightly greenish micaceous shaly sandstone.
800′
16′ coarse greenish micaceous cross-bedded sandstone.
2′ greenish micaceous sandy shale.
30′ coarse greenish conglomeratic sandstone, containing pockets of pebbles and stem impressions, and weathering concretionary.
9′ thin greenish micaceous pebbly flags, including lenses of dark shale.
6′ coarse sandy shale, weathering concretionary.
18′ irregularly bedded conglomerates with small pebbles, some of which are greenstone.
6′ slightly greenish sandstone.
900′
28′ massive conglomerate, with poorly assorted pebbles, attaining the size of goose eggs.
2′ coarse greenish micaceous sandy shale.
20′ slightly greenish arkose conglomerate.
4′ greenish cross-bedded conglomeratic sandstone.
21′ massive conglomerate, with rounded but imperfectly assorted pebbles, a few of which are sandstone.
3′ dark shale and fire clay, with plant fragments.
25′ massive conglomerate, with poorly assorted pebbles, some of which are egg size.
Red B
4″ dark sandy shale (fossil plants).
BEDS.
44′ coarse greenish arkose pudding stone, with pebbles of greenish sandstone, shale, quartz, and conglomerate, mostly rounded.
12′ red muddy shale.
1,300′
25′ very soft greenish arkose pudding stone, with large rounded pebbles of quartz, sandstone, and shale.
8′ green sandstone.
16′ red mud beds.
TRANSITION
8′ coarse green arkose conglomerate in sharp contact on uneven surface of beds of red mud.
10′ red shale.
2′ greenish sandstone.
12′ red shale.
16′ 6″ coarse reddish arkose conglomerate, with quartz and shale pebbles.
1,400′
45′ red shale.
9′ yellowish green sandstone.
FORMATION.
21′ soft greenish arkose pudding, with coarse quartz, sandstone, and shale pebbles.



SECTION IN SHARP MOUNTAIN GAP, POTTSVILLE, PENNSYLVANIA. (CONTINUED FROM PL. CLXXXI.)

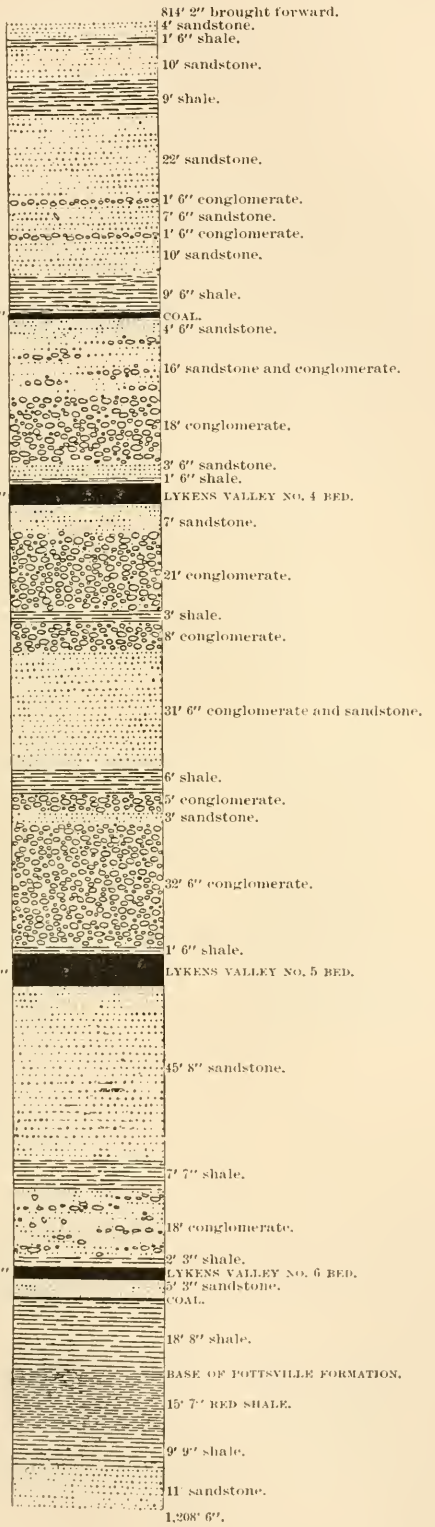
This plate represents the lower portion of the type section of the Pottsville formation and a portion of the Mauch Chunk (red shale) formation, including the transition beds.



SECTION OF THE POTTSVILLE FORMATION IN THE LINCOLN MINING DISTRICT.

Surface to roof of Lykens coal No. 5 in Lincoln colliery water-level tunnel, top of coal No. 5 downward into Mauch Chunk formation, Kalmia colliery water-level tunnel.

Scale: 1 inch = 50 feet.



SECTION OF THE POTTSVILLE FORMATION IN THE LINCOLN MINING DISTRICT. (CONTINUED FROM PL. CLXXXIII.)

This plate represents the lower portion of the Pottsville formation and the upper portion (transition beds) of the Mauch Chunk formation, Kalmia colliery water-level tunnel. Compiled from the State anthracite survey.

Scale: 1 inch=50 feet.

FIG. 1. RAUSCH GAP, SCHUYLKILL COUNTY, PENNSYLVANIA.

Section from the Twin coal to the top of the Mauch Chunk formation, showing the Pottsville formation.

1 inch = 200 feet.

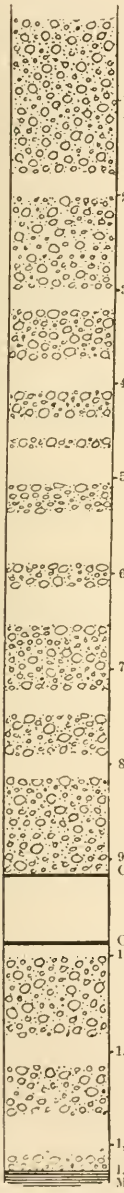


FIG. 2. LOCUST MOUNTAIN GAP, TAMAQUA, PENNSYLVANIA.

Section of the Pottsville formation, from the "A" coal to the top of the Mauch Chunk red shale.

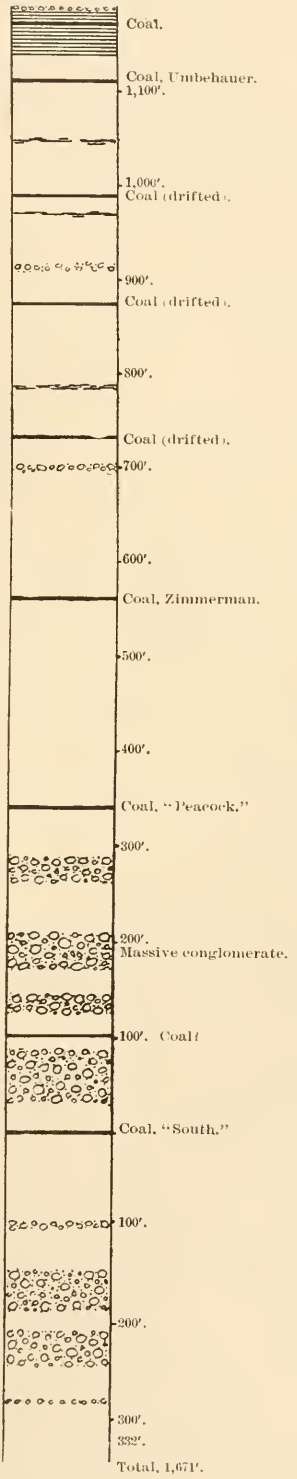
1 inch = 200 feet.

FIG. 3. LORBERRY GAP IN SHARP MOUNTAIN.

Section of exposed beds from the "furnace" coal downward. Datum line is "South" coal.

1 inch = 200 feet.

FIG. 3—Continued.



SECTIONS OF LOCUST MOUNTAIN AT TAMAQUA AND OF SHARP MOUNTAIN AT RAUSCH GAP, SCHUYLKILL COUNTY, AND AT LORBERRY GAP.

FIG. 1. FISHING CREEK GAP, TWO MILES NORTH OF ELLWOOD, PENNSYLVANIA.

Section including the coals opened within 500 feet of the red shale on the east side of the gap. Datum line is lower coal mined.

1 inch = 200 feet.

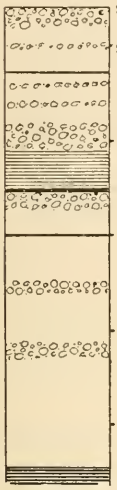


FIG. 2. BLACK SPRING GAP (MOUNT EAGLE), LEBANON COUNTY, PENNSYLVANIA.

Section from the "Black Spring" coal to the Mauch Chunk red shale, including the Pottsville formation and a portion of the succeeding Coal Measures. Datum line is the approximate horizon of the Twin coal.

1 inch = 200 feet.

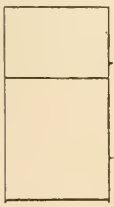
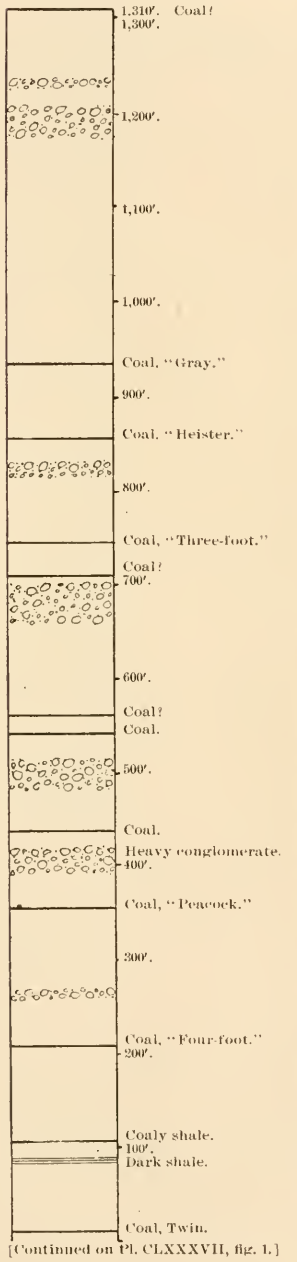


FIG. 2.—Continued.

FIG. 3. GOLD MINE GAP, LEBANON COUNTY, PENNSYLVANIA.

Section showing exposed terranes of the Pottsville formation and a portion of the overlying Coal Measures. Datum line is approximate horizon of the Twin coal.

1 inch = 200 feet.



[Continued on Pl. CLXXXVII, fig. 1.]

SECTIONS AT FISHING CREEK GAP, BLACK SPRING GAP, AND GOLD MINE GAP.

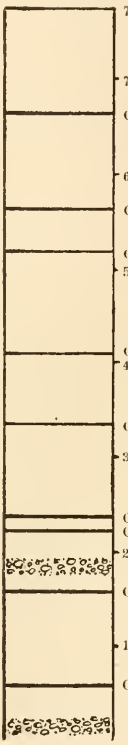
FIG. 1. GOLD MINE GAP, LEBANON COUNTY, PENNSYLVANIA—Continued from Pl. CLXXXVI, fig. 3.

Portion comprising the Pottsville formation between the Twin coal and the Mauch Chunk red shale.

FIG. 2. RAUSCH GAP, LEBANON COUNTY, PENNSYLVANIA.

Section showing exposures of the Pottsville formation and a portion of the succeeding Coal Measures. Datum line is approximate horizon of the Twin coal.

1 inch = 200 feet.



[Continued in next column.]

FIG. 2—Continued to show that portion comprising the Pottsville formation between the approximate horizon of the Twin coal and the Mauch Chunk red shale.

SECTIONS AT GOLD MINE GAP AND RAUSCH GAP, LEBANON COUNTY, PENNSYLVANIA.

PLATE CLXXXVIII.

PLATE CLXXXVIII.

SPHENOPTERIS PATENTISSIMA (Ett.) Schimp.

(Page 880.)

Fig. 1. This specimen shows the lax habit of the species and the deeply dissected distant pinnules. Lykens coal No. 5 (?), Lincoln colliery.

Lower Lykens division—Lower zone.

NEUROPTERIS POCAHONTAS var. PENTIAS D. W.

(Page 892.)

Fig. 2. Apical fragment, showing triangular form of upper pinnules. From Lykens coal No. 6 at East Brookside colliery.

Fig. 3. From Lykens coals No. 5 or 6 at Kalmia colliery.

Fig. 3*a*. Pinnule from the original of fig. 3, showing the fine nervation, which is Callipteridioid at the base. Twice the natural size.

Fig. 4. A fragment with lobate pinnules. From Lykens coal No. 5 at the Lincoln mine.

Lower Lykens division—Lower zone.

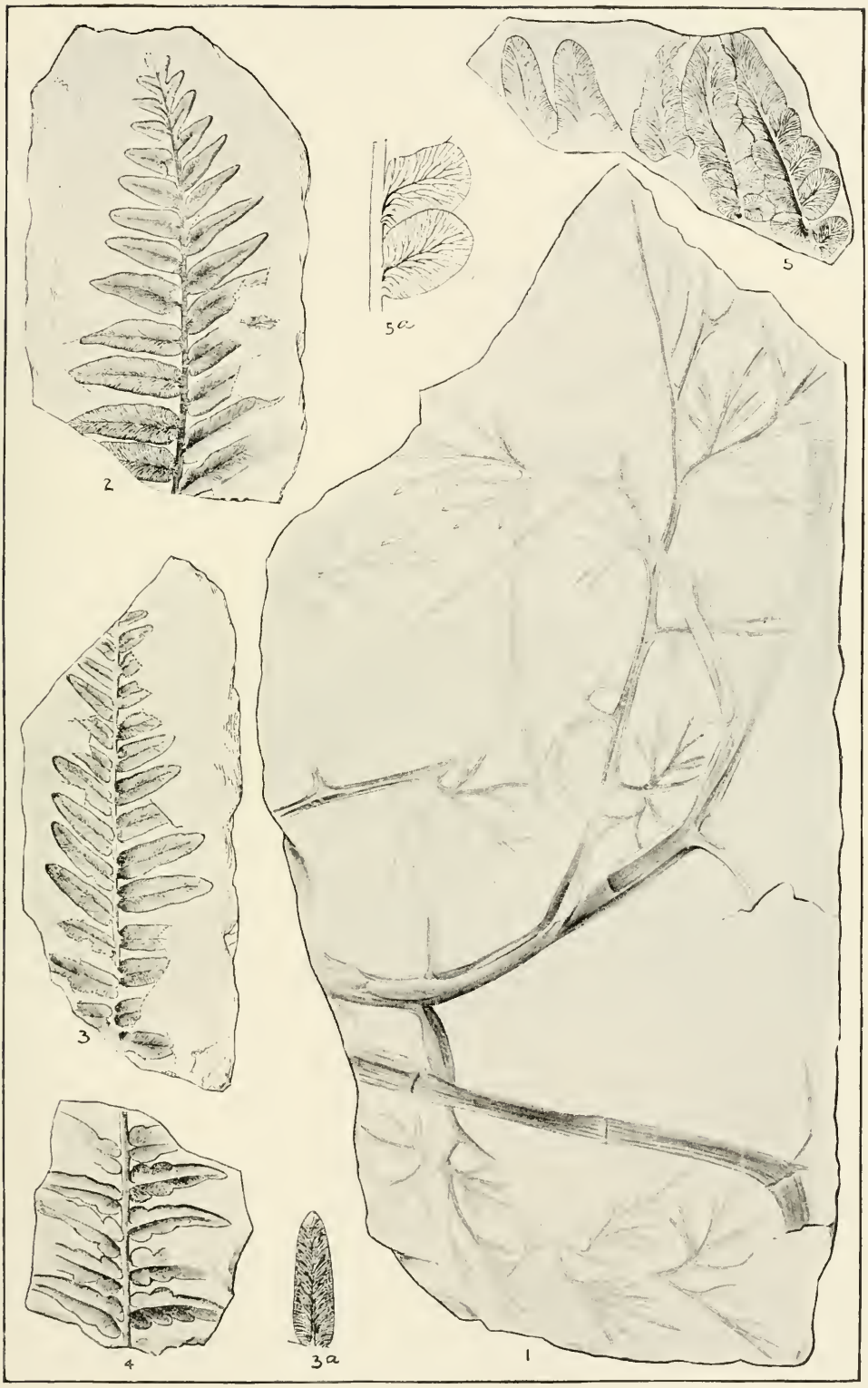
NEUROPTERIS POCAHONTAS var. INÆQUALIS D. W.

(Page 890.)

Fig. 5. Fragment showing Odontopteroid pinnules of the upper pinnæ. Bed D, 710 feet below the Twin coal in the gap at Pottsville.

Fig. 5*a*. Enlarged detail showing the nervation of two of the pinnules illustrated in fig. 5. Twice the natural size.

Lower Lykens division.



SPHENOPTERIS AND NEUROPTERIS.

Lower Lykens division.

PLATE CLXXXIX.

PLATE CLXXXIX.

Mariopteris eremopteroides D. W.

(Page 872.)

Fig. 1. Portion of slab containing segment of rachis, showing lateral compound pinnæ. Lykens coal No. 5, Brookside colliery.

Fig. 2. Fragment in which the pinnules are more deeply dissected and flattened. From the same locality.

Fig. 3. Fragment from the large lateral pinnæ shown in fig. 1.

Fig. 3*a* Pinnule of the same specimen enlarged to show the nervation. Twice the natural size.

Lower Lykens division—Lower zone.

Neuropteris Pocahontas D. W.

(Page 888.)

Fig. 4. Specimen showing the characteristic form and development of the pinnules of this species. From the roof of the Pocahontas coal near Crozers, in the Great Flat Top coal field, West Virginia.

Fig. 4*a*. Pinnule of the same specimen enlarged to show the nervation. Twice the natural size.

Age of the Lower Lykens division.

Neuropteris Pocahontas var. pentas D. W.

(Page 892.)

Fig. 5. Upper pinnæ and succeeding sublobate pinnules. From the roof of Lykens coals 5 or 6 at the Brookside colliery.

Fig. 5*a*. Sublobate pinnule, enlarged to show close, relatively parallel nervation. Three times the natural size.

Fig. 5*b*. Fragment from the lamina of the same pinnule. Enlarged to illustrate the interneural striation.

Lower Lykens division—Lower zone.


4
4a
5
5a
5b

MARIOPTERIS AND NEUROPTERIS.

Lower Lykens division.

PLATE CXC.

PLATE CXC.

ANEIMITES POTTSVILLENSIS D. W.

(Page 868.)

Figs. 1 and 2. The fragments show the small cuneate upper pinnules and the larger Adiantitoid form. From the roof of Lykens coal No. 4, at the Lincoln colliery.

Lower Lykens division—Mariopteris pottsvillea zone.

MARIOPTERIS POTTSVILLEA D. W.

(Page 874.)

Figs. 3, 4, 5, and 6. Figs. 3 and 4 represent the typical developments of the pinnæ and pinnules of this well-marked species; fig. 5 shows the apex of a compound pinna, while fig. 6 represents a fragment in which the pinnules are much more than usually close. Specimens from the roof of Lykens coal No. 4, at the Lincoln colliery.

Fig. 3*a*. Enlarged detail of one of the pinnæ shown in fig. 3, illustrating the lobes and nervation. Twice the natural size.

Fig. 4*a*. Similar detail from the original of fig. 4. The fossil is somewhat distorted by pressure in the shales. Twice the natural size.

Lower Lykens division—Mariopteris pottsvillea zone.

NEUROPTERIS POCAHONTAS var. INÆQUALIS D. W.

(Page 890.)

Figs. 7 and 8. These specimens show the elongated pinnules with Callipteridioid bases, such as occur in the middle and upper portions of the pinnæ. The specimen shown in fig. 7 is from bed D, 710 feet below the Twin coal in the gap at Pottsville; the original of fig. 8 is from the Kalmia colliery.

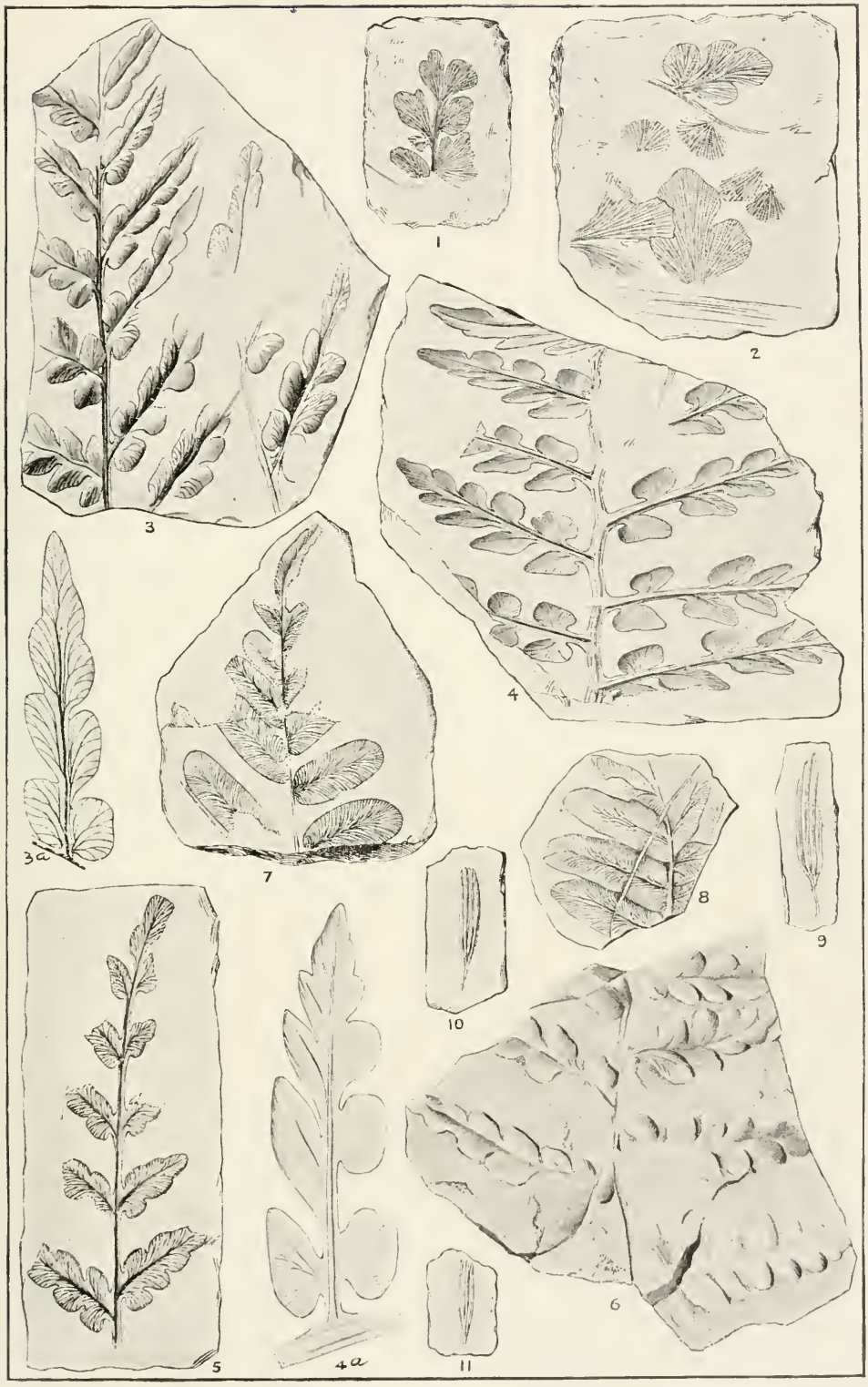
Lower Lykens division.

WHITTLESEYA CAMPBELLI D. W.

(Page 905.)

Figs. 9, 10, and 11. These specimens show the characteristic aspect of the fasicular ribs terminating in blunt, often obscure teeth, and the very slender petioles of the leaves of this species. The originals of figs. 9 and 11 are from beds H and D, respectively, in the section of the gap at Pottsville; the specimen shown in fig. 10 comes from the roof of Lykens coal No. 5 or No. 6 at the Lincoln colliery.

Lower and Upper Lykens divisions.



ANEIMITES, MARIOPTERIS, NEUROPTERIS, AND WHITTLESEYA.

Figs. 1–8. Lower Lykens division.

PLATE CXCI.

PLATE CXCI.

Neuropteris Pocahontas var. inæqualis D. W.

(Page 890.)

Figs. 1–4. Figs. 1 and 2 show the characteristic development of the pinnules in the small pinnæ. Fig. 2a shows a pinnule from the original of fig. 2, enlarged to twice the natural size, to illustrate the nervation. Fig. 3 includes pinnules with the elongated form, constricted at the base, immediately above the pinnatifid pinnules. The specimen shown in fig. 4 is drawn twice the natural size, to show the characteristic outline of the base of the pinnule and the nervation. The original of fig. 1 is from the drift on the east side of Rausch Gap; that of fig. 2 is from the Kalmia colliery; that of fig. 3 was obtained from the roof of Lykens coal No. 4 at the Lincoln mine; the original of fig. 4 comes from bed D, 710 feet below the Twin coal, in the gap at Pottsville.

Lower Lykens division.

Neuropteris Pocahontas D. W.

(Page 888.)

Fig. 5. This specimen shows the smaller upper lateral pinnæ, suggestive in form and size of the *Neuropteris Smithsii* Lx. The lateral pinnules are, however, clearly seen to be broadly attached to the rachis, the nervation being Odontopteroid, the midrib scarcely developed. From the roof of the Pocahontas coal at Gilliam, West Virginia, Pocahontas quadrangle.

Fig. 5a. Enlarged detail of pinna in the original of fig. 5, showing the form of the pinnules and the nervation. Twice the natural size.

Age of the Lower Lykens division.

Sphenophyllum tenue D. W.

(Page 901.)

Figs. 6 and 7. The figures show the slender, narrowed bases of the pinnules and the round-truncate, crenulate, distal margins. A fragment of one of the deeply dissected leaves from a verticel at the point of ramification is shown in fig. 6. The original of fig. 6 is from the Clark formation at Smith's Store, Virginia, Pocahontas quadrangle; that of fig. 7 is from the Pottsville at Warrior, Alabama (No. 8501 of the Lacoe collection, United States National Museum).

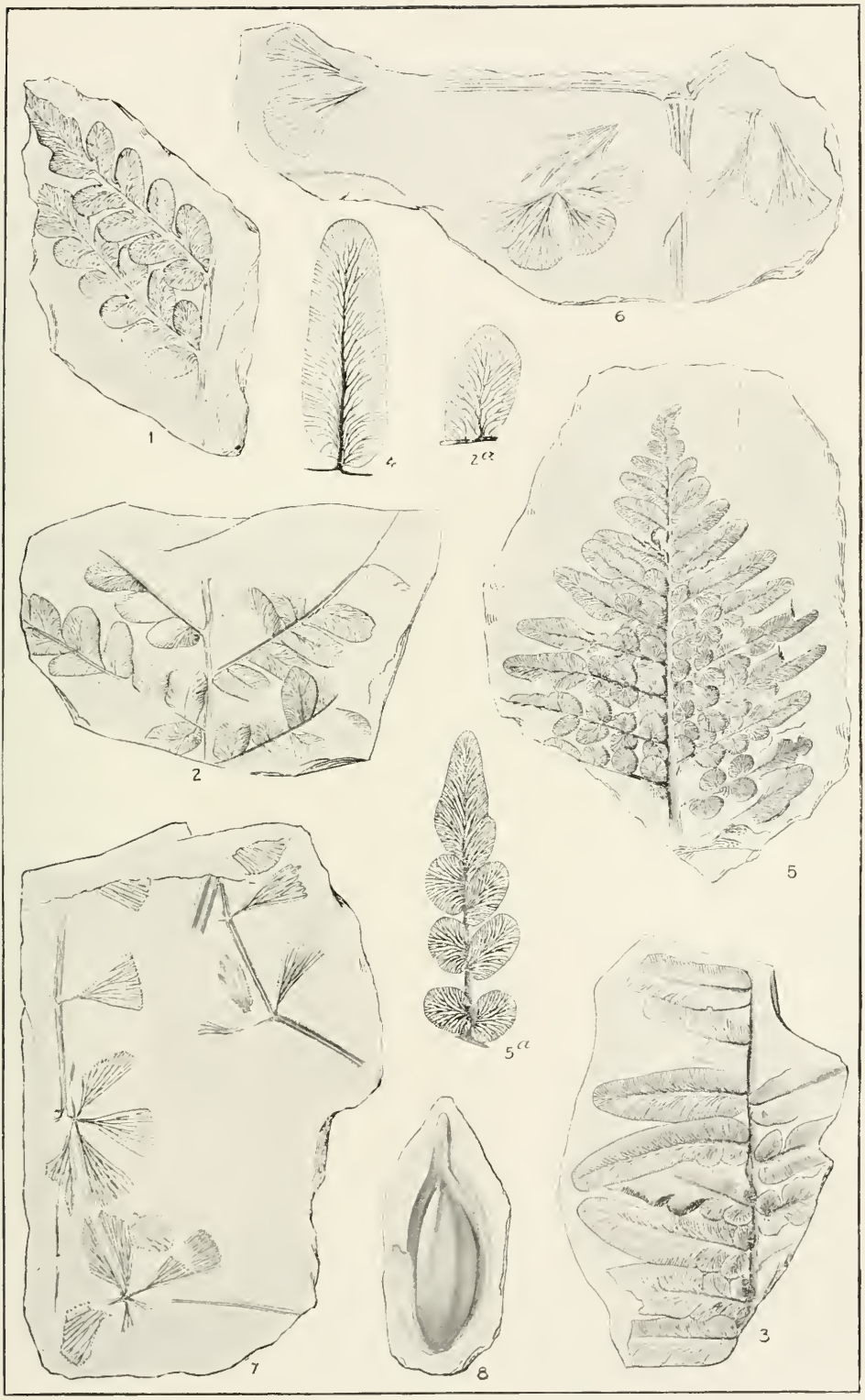
Lower Lykens division—Mariopteris pottsvillea zone.

Trigonocarpum ampullæforme Lx. var. spectabile D. W.

(Page 909.)

Fig. 8. This specimen shows well the thin, rather broad wings, the elongated micropylar neck, and the faint subordinate costæ. The specimen is from the Lincoln colliery.

Upper Lykens division.



NEUROPTERIS, SPHENOPHYLLUM, AND TRIGONOCARPUM

Figs. 1–7. Lower Lykens division.

PLATE CXCII.

PLATE CXCII.

Eremopteris lincolniana D. W.

(Page 869.)

Fig. 1. Fragment imperfectly showing the development of the pinnæ and pinnules in the lower lateral pinnæ. From the roof of Lykens coal No. 2 (?) at the New Lincoln mine.

Fig. 1a. Enlarged detail from the same specimen, showing the nervation. Twice the natural size.

Upper Lykens division.

Mariopteris pygmæa D. W.

(Page 876.)

Figs. 2, 3, 4, 5, and 6. These specimens show the ordinary form and aspect of the pinnæ and pinnules of this species. The originals of figs. 2, 4, 5, and 6 are from the horizon of Lykens coal No. 2 at the New Lincoln colliery; the original of fig. 3 is from nearly the same horizon, at about 500 feet below the Twin coal, in the Pottsville Gap.

Figs. 4a and 6a. Enlarged details of pinnules of the originals of figs. 4 and 6, showing the subdivision of the pinnules and the nervation. Twice the natural size.

Upper Lykens division.

Alethopteris Evansii Lx.

(Page 887.)

Figs. 7 and 8. Fig. 7 represents the terminal portion of the compound pinna, while in fig. 8 fragments of lateral ultimate pinnæ are seen. Fig. 7 is from the Lincoln colliery; fig. 8 was found in bed 11, 550 feet below the Twin coal, in the gap at Pottsville.

Fig. 7a. Enlarged detail of pinnule shown in fig. 7. Twice the natural size.

Fig. 8a. Detail of pinnule from the original of fig. 8, showing the nervation and the punctation of the lamina. Twice the natural size.

Upper Lykens division—Sharon zone.

EREMOPTERIS, MARIOPTERIS, AND ALETHOPTERIS.

Upper Lykens division.

PLATE CXCIII.

PLATE CXCIII.

ALETHOPTERIS LACOEI D. W.

(Page 881.)

Figs. 1 and 2. Typical fragments of the pinnæ of this species. From the roof of Lykens coal No. 2 at the lower Eureka tunnel.

Fig. 1a. Enlarged pinnule from the fragment shown on the left of fig. 1, illustrating the nervation. Twice the natural size.

Upper Lykens division—Servance zone.

NEUROPTERIS LUNATA D. W.

(Page 895.)

Figs. 3–7. Specimens showing the variation in form and size of the pinnules of this species. The originals of figs. 3, 4, and 5 are from the roof of Lykens coal No. 1 at the Lincoln colliery; the type of fig. 6 is from the rock dump at the same colliery; that of fig. 7 is from probably the same horizon at the New Lincoln colliery.

Figs. 5a, 6a, 7a. Enlarged details from the originals of figs. 5, 6, and 7, showing the thin, outward-curved nervation. Twice the natural size.

Upper Lykens division.

SPHENOPHYLLUM TENERRIMUM Ett. var. ELONGATUM D. W.

(Page 898.)

Figs. 8 and 9. Specimens illustrating the aspect of fragments of this species, in which the apices of the slender, rather lax, leaflets are usually buried in the matrix or broken away. The specimens are from the New Lincoln colliery, where they probably occur in the roof of Lykens coal No. 2.

Fig. 8a. Enlarged detail, showing the division and nervation of a young leaflet of this species. Twice the natural size.

Upper Lykens division.

CARDIOCARPON CORNUTUM Dn.

(Page 908.)

Fig. 10. Ordinary example; from bed 11, 550 feet below the Twin coal, in the gap at Pottsville.

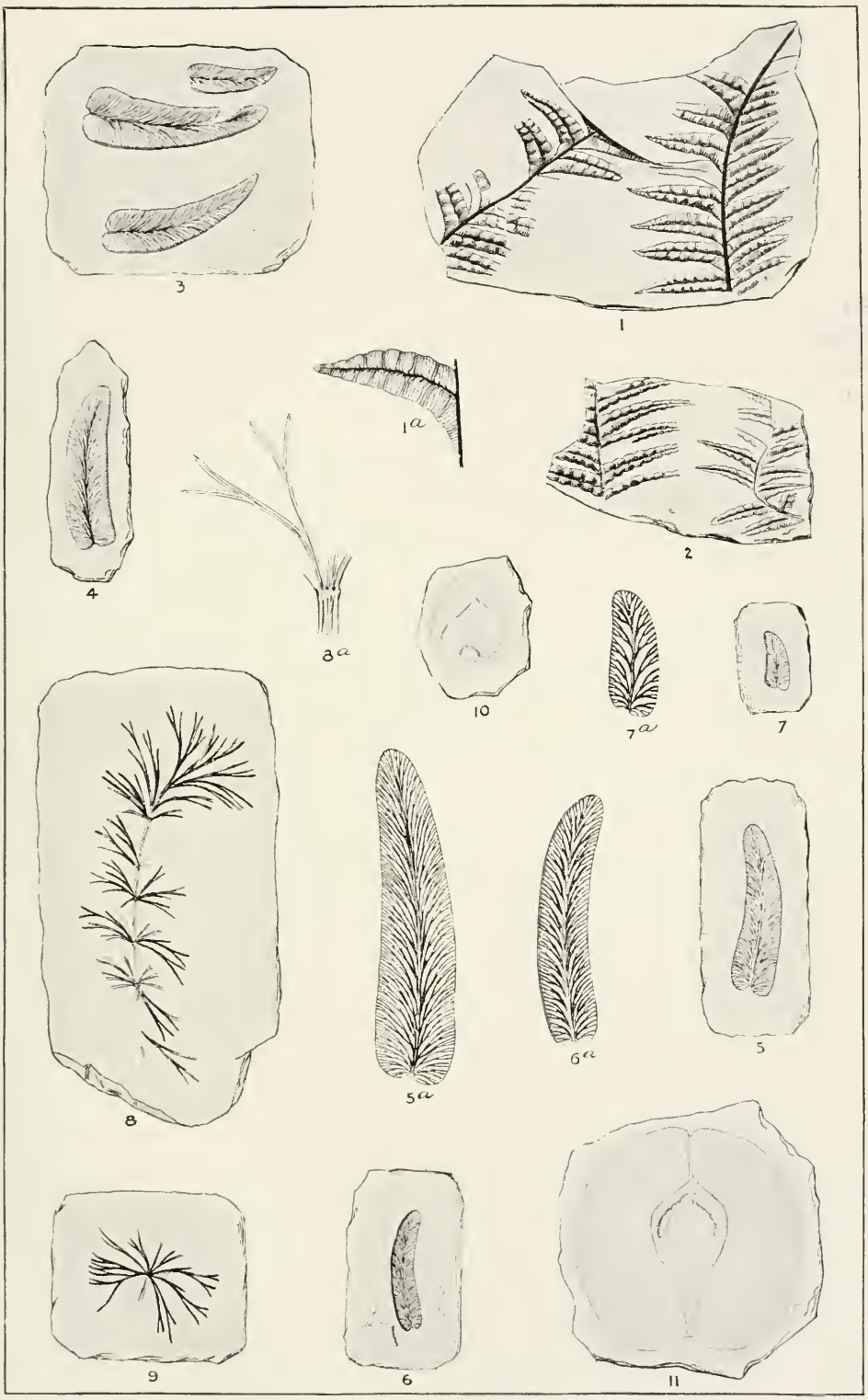
Upper Lykens division.

CARDIOCARPON GIRTYI D. W.

(Page 907.)

Fig. 11. This specimen shows the very broad, thin wing, dilated in the lower portion, which is traversed by an obscure cuneate chalaza. The latter is delineated more distinctly than it appears in the original. The specimen is from the roof of Lykens coal No. 2 (or 1?) at the New Lincoln colliery.

Upper Lykens division.



ALETHOPTERIS NEUROPTERIS, SPHENOPHYLLUM, AND CARDIOCARPON.

Upper Lykens division.